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Reading by Sound. ON another page we publish an interesting little contribution to the history of the electric telegraph in the form of a fac-simile of a letter from Samuel F. B. Morse to his friend Elijah Paine, Jr.; the latter's epistle, to which the one given is the reply, is annexed for explanation. The point at issue was the question of reading by sound, which seems to have entered into the minds of more than one of the pioneers of telegraphy. Judge Paine, as acute in science as in law, appears to have appreciated at once the advantage of reading by sound instead of going through the tedious process of making a record, and was quick to suggest the improvement. It is, however, singularly interesting to know that at that early day Morse had not only tried several devices for making receiving by the ear easy, but had himself been for some time in the habit of recording the messages from the click of the lever, just as is done by every telegrapher of to-day. This exceedingly simple method eventually was found to possess all the advantages of a printed record, and naturally quite superseded any efforts at distinguishing dots from dashes by the quality rather than the length of the sounds. Morse was too quick witted not to perceive this, and whoever may have been the first to introduce the method into every-day telegraphic service, the inventor of modern telegraphy was himself the pioneer in its employment.

Annual Meeting of the Institute. AS we go to press the American Institute of Electrical Engineers is beginning its annual meeting in this city. The programme we have given previously in these pages. Commencing with the business meeting on Tuesday evening and ending with the reception courteously tendered to the Engineers by the Electric Club, two full days are devoted to the discussion of electrical problems. The meeting in Boston last year was an unqualified success, and was made noteworthy by several papers of exceptional value. The present one is in no wise behind its predecessor in general importance. The American Institute of Electrical Engineers is to-day the only representative electrical body in the country, and every year it is prepared to exert a stronger influence in its particular field. During the past year the membership has considerably increased, and the activity of the organization has more than kept pace with its growth in numbers. Perhaps the most satisfactory work of the year just closed has been the introduction of the henry as the practical unit of self-induction. The proposition was brought forward and has been earnestly pushed by Prof. F. B. Crocker, of Columbia College, with the result that not only has the name received the endorsement of the Institute, but has made its way into every-day use both in this country and abroad, so that it may already be said to have become a part of our recognized electrical nomenclature. The outlook for the coming year is one of increasing prosperity and added opportunities for usefulness.

The Portelectric System. ON another page we give, for the edification of our readers, the report by Mr. F. L Pope on the Portelectric system. It is, as will be seen, somewhat guarded, but on the whole rather favorable. Perhaps the best thing that can be said of the system in question is that it has obtained the support of two electricians as well known as Mr. Pope and Prof. Dolbear, the latter having been connected with the company since its organization. The efficiency of the apparatus appears to be higher than might at first sight be supposed, and considering the character of the track and the experimental nature of the whole plant, 60 per cent. efficiency is decidedly creditable. The speed developed has been up to the present a disappointment, but, as Mr. Pope points out, there is at least a fighting chance for obtaining vastly better results by running over a straight and well-laid track instead of the rough temporary line used in the experiments. There is such a thing as imposing too exacting tasks on experimental apparatus, with the result, sometimes, of introducing conditions that never would be approached in everyday practice, and straining the apparatus in a way for which it never was intended. Aside from this it ought to be remembered, in considering the Portelectric system, that it has a very considerable application quite apart from its use for rapid transit over long distances; it may prove to be a more successful rival of the pneumatic tube than of the railway, for it is in work like the former that such apparatus shows itself at its very best. In fact, to its use as a mail carrier over long distances it might be objected that it would give facilities for robbing the mails as yet unequaled in the history of the post-office department, for inasmuch as the flying car is completely without guardians on the route, unless the entire line were patrolled, a brickbat carefully wedged in the track would place the mail at the mercy of any person who cared to investigate it with thievish intent. While the cost of the line is somewhat high, it is not at all prohibitive, and where, as in service over limited distances, the line can be completely shut in, the multiplicity of switches will not continue to be the source of the trouble that might be expected in exposed situations.

A Dangerous Combination. SOME few weeks ago we called attention to an exquisitely disingenuous bill then before the Legislature designed to give over into the hands of electric companies using low-tension currents the subway interests of New York city. As we then mentioned, the controlling interests involved were the Western Union Telegraph Company and the Metropolitan Telephone Company, with the Bell Telephone Company and the Edison Electric Company as enthusiastic participants. The nominal purpose of the bill in question was to permit the organization of a body known as the Empire City Subway Company for the purpose of building all the low-tension subways and taking up such other work of the Consolidated Subway Company as might seem desirable. On the face of it the proposition might be supposed to facilitate the construction of the much-needed electrical conduits and aid the electrical development of the city; on looking deeper, however, it appears to be a carefully planned and unfortunately successful attempt to gain permanent control of the electrical systems of New York for the pecuniary benefit of three or four grasping corporations. It is generally understood that the Empire Subway Company belongs body and soul to the four organizations just mentioned, and the result of the bill that has just become a law and the following authorization by the Board of Electrical Control will be to put the telegraph and telephone interests permanently and completely into the power of the Western Union and the Metropolitan companies. The former has shown itself always willing to gobble up competitors in the past, and the latter will doubtless find it very convenient after 1893 to prevent the establishment of rival exchanges. Incidentally the Edison company, that succeeded in obtaining the right denied to others of building its own conduits, will be enabled, if it should see fit, to block the progress of conduits intended for high-tension wires at any time and to any extent that it pleases. For the general public, however, the tremendous power given to the telephone monopoly is probably the most undesirable feature of this objectionable combination. It is hardly possible that the new company will be permitted to assume complete control of the city without further legal complications. What their result will be no one can tell. Altogether, the present chapter in the history of the subway machinations is the most important in the annals of this misgoverned metropolis.

Why Do the Heathen Rage? THE latest opposition to the trolley system comes from the people of Mt. Vernon, N. Y., who have been carefully worked up to the point of making most vigorous objections to the proposed improvement. The daily press, as usual, has taken the matter up, and gravely asserts that the trolley wire must be a constant menace to public safety and a common cause of fatalities. It is also calmly stated that the wires in Pittsburgh, Boston and other places cause death to animals and individuals upon whom they fall. It would be interesting to know the real source of the opposition that the trolley system encounters from the press. The editors of our large metropolitan papers are, as a rule, very well posted on subjects of current interest, and certainly are wide awake enough to inform themselves. Nevertheless, assertions such as those quoted are common and are repeated over and over again in spite of their manifest untruth. If there had been a single fatal accident to any human being from the trolley wire since the electric railway first came into use, there might be some slight cause for these sweeping statements, but, as a matter of fact, no such accident has ever occurred, and in hundreds of cases where shocks have been received by employés of railway companies no serious damage has resulted. The alleged fatality of the trolley wire has thus been tested again and again under all sorts of circumstances and in all parts of the country, with the uniform result of showing that the current used is not dangerous to human life; and not only this, but no scrap of evidence has ever been produced, or is likely to be produced, to prove the contrary. The only case that has even been reported was that of a small colored boy in a Western town, who was said to have been found dying under the car he was cleaning, "stricken down by the deadly current." On investigation it was shown that he had fallen asleep over his work and had set his clothes on fire with the torch by the light of which he was working. In view of these facts the continuance of such attacks on the overhead system is puzzling, not to say suspicious. Such persistent opposition cannot be without cause, and it certainly is worth while finding out its real source. The electric railway companies could do no better work than in analyzing these unreasonable attacks and searching out the instigators. So far from being a "constant source of menace" to the public safety, it is an open question whether the trolley system as it is could not be introduced even on metropolitan lines with entire safety and with the result of vastly improving facilities for rapid transit. On this point we can do no better than to put conspicuously before the public the opinions of three engineers whose long experience with electric traction under all kinds of conditions certainly ought to make them competent judges of its weak points. One of these three is Mr. F. H. Monks, the general manager of the largest electric railway system in the world, who, during the past year or two, has had the widest possible opportunity of observing the effects of the "deadly" trolley wire on the West End Railroad, in Boston. Another is Mr. O. T. Crosby, who, from his long connection with railway interests, has become thoroughly familiar with electric roads under all sorts of conditions, and who is known all over the world as an expert on the subject. The third is Mr. J. C. Henry, one of the pioneers of electric traction, who was laboriously experimenting on the subject long before the present electric railway became known, and who has followed its development throughout its entire history. If experts of such experience are not competent to speak of the real facts regarding the application of the trolley system, it is impossible to find those who are. We have hammered away at the popular prejudice on this subject steadily and persistently, and take pleasure in now presenting the singularly accordant and emphatic views of others. To raise the question in the most forcible way the application of the trolley system to the Broadway line is the particular hypothetical case discussed.

Latest Fore gn Electrical News.

(*By cable from our regular correspondent.*)

London, May 18, 1891.—The discussion of Dr. J. A. Fleming's paper before the Institution of Electrical Engineers on the Ferranti effect provoked a debate of a very lively character; the principal speakers were Prof. W. E. Ayrton, James Swinburne, Sydney Evershed and G. L. Addenbrooke.

The petition on behalf of the owners of the Jablochkoff distribution patent for a prolongation of its life has been rejected; royalties on account of this particular patent have been levied from transformer companies continuously during the past two years.

Electric street lighting in the city of London is expected to commence in June.

The Trolley System for City Service.

BY F. H. MONKS, O. T. CROSBY AND J. C. HENRY.

Opinion of F. H. Monks.

"Would it be practicable to employ safely and effectively a well constructed overhead system on the heavily loaded Broadway line?" In answer to this I beg to say that as a result of my experience and observation respecting the use of electricity as a motive power for street railways, I am thoroughly convinced of its great present and prospective value; in fact, I believe it to be the most valuable motive-power agent (both the public interest and that of the transportation companies being considered) for the purpose named now extant, and that the sole question to be settled respecting its use in conjunction with the electrical motor is the matter of its application. Perhaps the ideal system of application is through the accumulator or storage battery. But can it be shown that any storage battery system has proved commercially successful after thorough and practical tests actually conducted for a period of 12 months upon a city road? Storage battery cars have been exhaustively tried in England for several years, and the latest reports from that country show that no degree of commercial success has been attained to date. The result in this country seems to be the same. Now and again we have been assured that a new invention in the storage battery field has been found, which will surely meet with commercial success in operation, but the report of actual tests and results in proof thereof is lacking. Personally, I have faith to believe it will come some day. Perhaps it is near at hand. Who knows?

The conduit system has been thoroughly tested, and has been shown to possess no commercial value for the propulsion of street cars to date.

The only system for the operation of street cars by electricity which has, up to date, met with commercial success is the overhead wire system, and, therefore, the application of electricity as a motive force at present must be confined practically to that system. In other words, if we would to-day use electricity as a motive power to commercially operate on street cars, we must be limited to the selection of the overhead wire system. The extension of the overhead system in the large cities of the country has undeniably been greatly checked by the opposition of the municipal authorities to the erection of poles, the stringing of wires, the fear that loss of life or injury to persons would ensue as an inevitable result of the operation of cars by electricity, and the belief that any line so operated would of necessity succumb to the rigors of a Northern winter. Notwithstanding such opposition, the number of roads operated by the overhead wire system has increased with great rapidity, and after the people have had an opportunity to learn to their complete satisfaction that the poles and wires, though certainly objectionable, are yet justifiable under the circumstances, that absolutely no one is killed by the electrical current and that no snow storm, however severe, has any terrors for the managers of the line, they clamor for the rapid extension of the system, as they certainly are doing in Boston to-day. How soon will you put electric cars into our section? is a frequent question. The construction necessary to start an electric road on a large scale, or the reconstruction necessary to convert a horse road into an electric road is very great, and in the latter case must cover in almost every instance track, car houses, cars, etc., while at the same time the loss on stable property is, of course, great. The progress of invention respecting the development of the overhead system has been marvelous, and the great danger has been the possibility of getting too far committed to present methods and appliances to prevent the acquirement of the improved devices, which are coming into sight almost daily. These facts have unquestionably acted as a deterrent with street railway managers everywhere to the even more rapid extension of the overhead system. I make no doubt but that within a few months matters of detail respecting this system will be so generally regarded as settled that its extension will be more rapid than in the past. Having given you the result of my experience and observation respecting this matter, I will now answer your question by stating that in my opinion it is entirely practicable to operate the Broadway line of cars with safety, comfort, certainty and to the satisfaction of the public, and also with economy and satisfaction to the company, by a well constructed and well operated overhead wire electric system.

Opinion of O. T. Crosby.

It goes without saying that an ordinary overhead structure, consisting of iron poles, span, guard, trolley and feed wires, would be far less objectionable than is to-day imagined by those citizens of New York who most strenuously oppose the electric system. This overhead work is now familiar to the inhabitants of a majority of the great cities of this country. As a matter of fact, few of them ever look at, or think of, the wires. Being engrossed, in true American fashion, in going from point to point in the most expeditious and comfortable manner, they accept the swift, bright electric cars as the "right thing in the right place." They do not appreciate the horrors of their situation until they read, in New York journals, of the atrocities they have been daily enjoying.

If, however, the erection of poles along Broadway were considered as the only unpardonable crime connected with the work it would be, from an engineering standpoint, easy to satisfy the public mentors and yet accomplish our fiendish purpose of giving the most rapid and generally the best service possible over the surface of Broadway. Save at Union and Madison squares and Forty-eighth street, we find along the present Broadway line walls on both sides broken only by the cross streets. Support for $\frac{99}{100}$ of the span wires needed is thus at once offered, and this support can be had without present defacement or prospective danger to the houses to whose front walls attachment might be made. Further, the feed wires can well afford along such a line to be buried, in which case no overhead, current-carrying, longitudinal wire would be nearer to any house than is the axis of the nearest street-car track. Further, if it be supposed that other wires shall have been placed underground or that those remaining overhead, except the trolley wires, be well insulated, then guard wires may be dispensed with, and only two longitudinal wires and the cross or span wires (say 125 feet apart) would appear to represent the "obstruction," whose existence could be alleged as a sacrifice made for the obtainment of *good* surface transit. If, however, the guard wires be erected, as they are at present used in Boston and elsewhere, the "obstruction" is still of no consequence; it is 20 feet above ground, while it permits on the street, where lies the interest of the multitude, a space-economy due to the absence of horses, two to every car, occupying about 10 feet by 5 feet per car. Removals of stables from populous neighborhoods, relative cleanliness of streets, good illumination of cars, running of trail cars when needed—all these incidental advantages, in addition to the prime advantage of *rapid transit*, are familiar to some millions of Americans who daily use the electric system. Yet we must be prepared to meet in New York a public opinion which makes no measure of the good done, but resolutely buries its head in the sand and cries out against the "terrible trolley."

Opinion of J. C. Henry.

During a residence of the past 18 months in this city I have, on frequent occasions, been provoked at the efforts of some of the metropolitan papers to write down and create public sentiment against what is called the trolley electric railroad system. Why this should arouse my special indignation may be inferred when I inform you I designed, constructed and operated the first electric road ever built with overhead wires, and that I have devoted the best years of my life to the development of this system. The criticism referred to, generally concerning the operation of existing roads with which I am familiar, has at times been so rank and far-fetched that it is perfectly apparent to those who are acquainted with the subject that something other than a desire to express the popular opinion has influenced writers. That electric motors are perfectly capable of operating street cars under certain conditions is an assured fact. In proof of this I have but to refer to the four thousand cars in daily operation under the trolley system in this country. How well they do it can readily be seen by an investigation of the different roads around this city. It is certain that none of the arts were ever brought forward so rapidly as the electric ones. This has been going through a course of development unparalleled in the history of the works of man. It has been a development, nevertheless. Perfection in mechanism has never sprung out Minerva-like, but has always followed the old way, "First the blade, then the ear, next the full corn in the ear." The early electric roads, although fit subjects for criticism, served a purpose; they demonstrated that it was possible to operate cars through this subtile agency; they also demonstrated that the early designs had some very unreliable and objectionable features which it has taken time to remove. The later-constructed roads seem to be improvements in many respects over other known systems of propelling street or suburban cars. In support of this statement I have to refer to 75 per cent. of the roads now under construction in this country. They are to be operated by the trolley system.

It must be conceded that New Yorkers are suffering for rapid transit on the streets, and a full canvass of the remedies should be encouraged. Animals are not powerful or quick enough to meet the requirements: they occupy as much room on the streets as the cars themselves, and are an impediment to other traffic; they assist in raising the dust, wearing out the pavement, and leave filth behind them. They cannot stop or start with the facility of cars operated by machinery. Cable or electric roads have none of those disadvantages. A selection must and will be made from these two systems. Which is it to be? There is room for argument in favor of both. It is admitted that the heaviest traffic streets in America are operated by cables, notably the Market street line in San Francisco and State street in Chicago, and that nothing can equal them on heavy grades. Fortunately for this city we have no streets with heavy grades; hence this advantage of the cable does not apply. The other reasoning can only be confronted by the fact that those roads referred to were in operation years before any electric ones were projected. Which is the best to-day should be the question.

I understand that it has been arranged to put cables on Broadway and on Third avenue. The best laid schemes are subject to changes. This seems to apply to cable railway projects.

In the city of Boston arrangements were completed to build many miles of cable railways there. The management heard of trolley roads in the West; they investigated them, they appreciated their advantages and changed their plans. As a result, passengers to-day reach their destination in the suburbs of Boston with more dispatch and comfort than is possible with the best designed cable road.

In Minneapolis and St. Paul the plans were changed. The material for an extensive cable plant is for sale cheap, and the citizens there are now enjoying the trolley system.

In Omaha an expensive cable plant which had been in operation for several years was abandoned and the trolley system substituted.

These changes have been made since it was first proposed to use cables in this city. In view of these facts is it reasonable to ask that the comparative merits of both systems should be carefully canvassed.

This city is on the eve of a great change. Asphalt pavements, elegant cars and rapid transit will make it more pleasant and desirable to do business in, and will put the finishing touches on the great metropolis. I believe the courted cable roads are not what is desired and that electric motors are, and will briefly refer to my reasons:

To build a cable road on Broadway of the most approved pattern would require excavations 4 feet deep and about 15 feet wide along the entire street; many gas and water pipes would have to be removed; the street in all probability would be torn up and partially blocked for a year, as the work can only be carried on during the building season. The residents know full well what this means—with a soil so polluted with gas that a single paving block cannot be removed without making the atmosphere offensive. Would they care to do business under the proposed conditions temporarily? If so, do they court having this escaping gas permanently with them? Cable conduits mean two open sewers the entire length of the street. They are certainly objectionable from a sanitary point of view.

Electric cars can be stopped much quicker than cable ones, for the reason that the propelling force can be instantly reversed. Cable cars necessarily run at a fixed rate of speed. Electric cars can be operated with the greatest certainty at any desired speed. An accident to an electric car means it must stop; accidents to grips or cables sometimes means the cars must go whether the road is clear or not. Imagine a heavy cable car going down lower Broadway with a snarl caught in its grip and no way of stopping it until word was sent to the power-house to shut down the engines. Such accidents are of frequent occurrence on cable roads. Does the dear public want such a road, or would they prefer the trolley system, which can readily be built under the following conditions:

First, no disturbance to the surface of the street, the main currents being carried in the already constructed subways; handsome metal poles, 20 to the mile, placed on opposite sides of the street, these poles constructed so as to carry street lamps and mail boxes; a thoroughly insulated cable stretched across the street between each set of poles; two light insulated wires 20 feet above and parallel with the street. This is a complete description of that bugbear, the trolley system, as it would appear in Broadway.

It is argued that these wires are dangerous. Electricians of reputation maintain that the pressure used for railroad work, *i. e.*, 500 volts, has never been known to kill an individual, no chances need be taken on this score; the cars would operate as well under half this electric pressure, say but 250 volts; it would simply require more copper in the subways.

A New Engineering Magazine.

The Engineering Magazine is the title of a monthly periodical, two numbers of which have already been issued from the publication office in the *World* building, this city. The size is about that of the *Century* or *Scribner's*, and it is well illustrated and printed. The field covered is, as the title indicates, a broad one, and the articles deal with topics of interest to the civil engineer, the architect, the mining and mechanical engineer and the electrician. Besides leading articles upon these subjects, each number contains a review of the publications of the month, together with abstracts of the principal papers that have appeared in the various weekly journals.

The Electrical Illumination of New York City's New Music Hall.

The observing student of electrical progress cannot have failed to notice a gradual but marked improvement in the methods employed in the last few years in the illuminating arrangements of large public halls and theatres. For the production of the most artistic effects, to say nothing of the improvement as a sanitary measure, gas has been entirely discarded; the cumbersome chandelier has been banished from its time-honored place in the centre of an otherwise handsome ceiling; the unsightly but once necessary fixtures are no longer needed; and the marvelous flexibility of the incandescent lighting system gives almost unlimited freedom to the architect in the design and arrangement of interior decorative effects. Perhaps no more admirable specimen of the beautiful effects which may be produced by a properly arranged system of incandescent lighting combined with the artistic decorations of a modern theatre of the best type can anywhere be found than that to be seen in the new Music Hall in this city. This building is located at the corner of Seventh avenue and Fifty-seventh street, and was opened to the public for the first time on the evening of May 5. Its lighting arrangements have not only proved satisfactory, but have been the admiration of the immense audiences that have gathered in the hall during the first week of its public use. In order to understand the methods by which these effects have been produced, it is necessary to know something of the general plan and construction of the building itself.

Music Hall was founded by Andrew Carnegie, who gave $1,000,000 of its total cost, which was something like 25 per cent. above this figure. It is controlled by the Music Hall Company of New York, Limited, of which Mr. Morris Reno is the president. The building is of brick, with terra cotta trimmings of various architectural forms. The principal doorways are approached by series of steps 80 feet broad, the various entrances being lighted by 150 lights arranged in groups in appropriate lanterns.

The chief feature of the interior is the main hall, an immense concert hall with a seating capacity of 3,000 and standing room for fully 1,000 more. Its entrance is on Fifty-seventh street, through the vestibule—a splendid apartment, 70 feet long, covered with a semi-circular vault 25 feet high, and richly elaborated in marble, mosaic and color. The hall was designed purely as a concert hall, and is not equipped in any way with theatrical devices; it has neither drop curtain nor footlights. The parquet itself, seating over 1,000 persons, has nine exits upon the corridors surrounding it, the corridors continuing entirely around the building. Above the parquet are two tiers of boxes, the dress circle and the balcony. The arrangement of these several tiers is different from the usual method in that they do not extend entirely around the three sides of the house, stopping at the line of the proscenium, but are terminated on the side walls at points further and further back from the front of the auditorium, gradually expanding the hall, displaying its peculiar shape, and naturally leading to the magnificent ceiling which spans the great apartment. Some idea of the size of the hall may be ormed when it is stated that a person standing at the rear of the balcony in the centre of the house is 186 feet from the middle of the stage.

The prevailing colors in the decoration of the main hall are a soft ivory white, gold and rose. The boxes are finished in darker shades of old rose and this color also prevails in the covering of the parquet chairs and in the carpets. The second great room in the building is known as "Recital Hall," and is located directly under the main hall. Its seating capacity is 1,200, and the decorations are similar to those of the main hall.

To properly illuminate the structure described above so that the beauty of the decorations might be in no way interfered with, so that the resulting effect would be a pleasing one and so that at the same time the lighting system would be safe and easily accessible in every part at all times, was the problem of the electrical engineer into whose hands the lighting of the entire building was given. That it has been admirably solved must be the opinion of every one, whether he views the resulting effect merely from the standpoint of the auditor who cares only for an æsthetic appearance, or from the more utilitarian point of view of the engineer who examines the plant to ascertain the character of the work done upon the mechanical details of the installation.

The lighting system used is the Thomson-Houston, the current being supplied by direct-current generators. The electrical equipment consists of four Thomson-Houston 80,000 watt compound wound dynamos wound for 125 volts and a maximum output of 640 ampères at that pressure. Each dynamo is driven by an independent Straight Line engine with a 15 × 16-inch cylinder, and making 220 revolutions per minute. As the dynamo-room is in the basement just behind the "Recital Hall," great care was taken in building the foundations. These are made exceptionally heavy, with granite cap stones eight feet square and 10 inches thick, with retaining walls maintaining an air space around each. This reduces the vibration which is transmitted to other parts of the building to a minimum.

Steam is supplied by three Root water-tube boilers arranged in two batteries, the single boiler being of 175 h. p. and each of the others of 150 h. p., or 475 h. p. in all. These boilers supply steam not only to the four electric light engines, but also to the eight small engines connected with the heating and ventilating system, the plant being arranged so that the exhaust steam from all the engines in the building is available for heating if desired. The entire steam plant, including the heating and ventilating apparatus, was erected from the plans and the specifications and under the direct supervision of Mr. Alfred R. Wolff, M. E., consulting engineer, Potter Building, New York City. The contractors for the electric light engines were Messrs. Williams & Potter, 15 Cortlandt street, New York City; for steam boilers, The Abendroth & Root Manufacturing Company, 28 Cliff street, New York City; and for the heating and ventilating apparatus, Messrs. Johnson & Morris, 114 Leonard street, New York City.

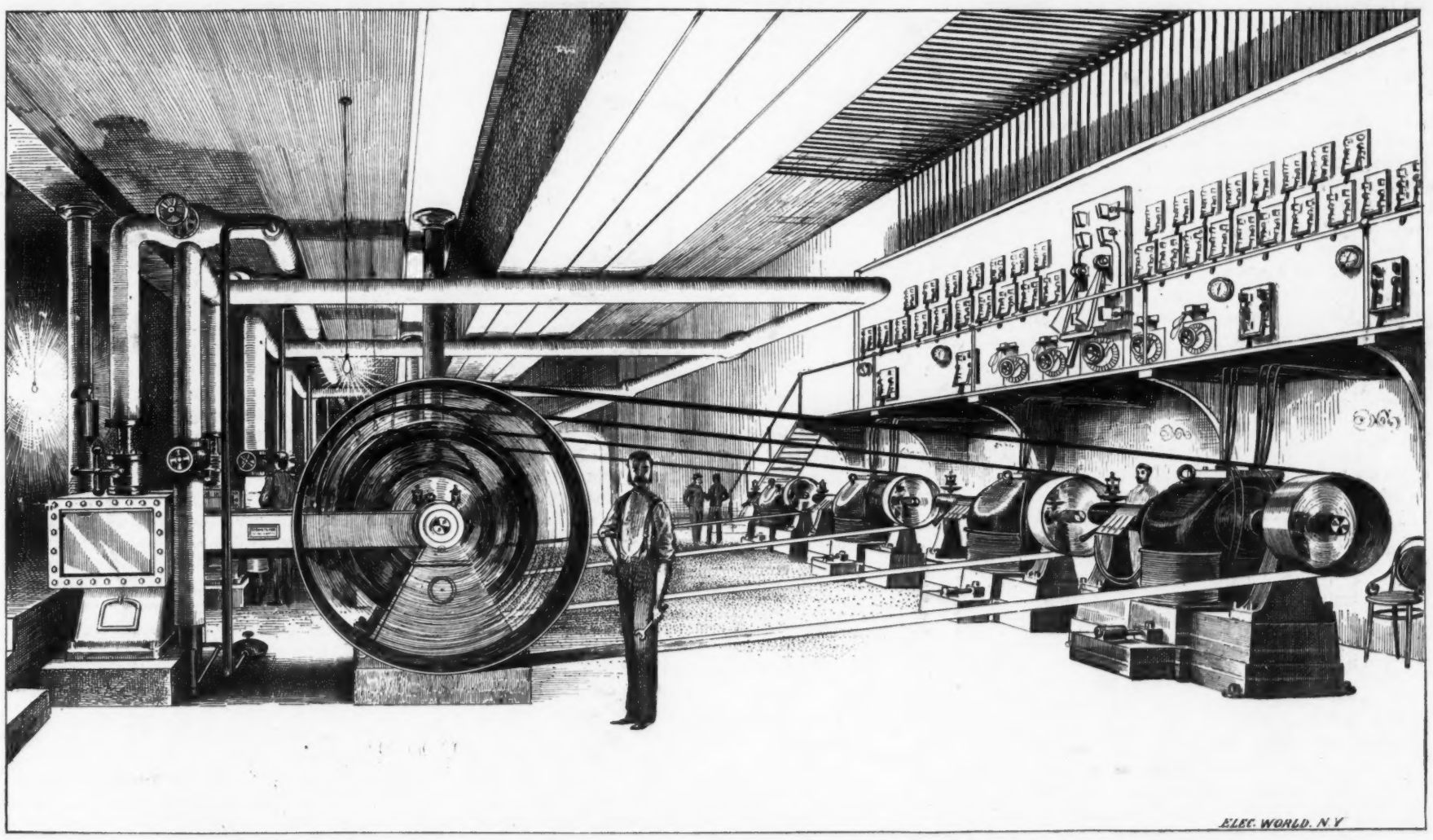
Upon one wall of the dynamo-room in an iron balcony is placed the main switchboard. This is of enameled slate, and is 25 feet long. Upon it are placed 37 switches, the rheostats, measuring instruments, etc. The main switch, which is six feet high, and is calculated to carry 2,400 ampères, is placed at the centre of the board. It is intended merely for reversing the direction of the current through the lamps. The lights in the main music hall and recital hall are controlled from two smaller switchboards conveniently located. The circuits to these latter, however, first pass through the main switchboard.

Each dynamo is provided with an independent rheostat for regulating the E. M. F. of the machine. A fifth rheostat of large capacity is provided, by means of which the E. M. F. of all the four generators may be regulated at once. This is accomplished by merely connecting the fifth rheostat in series with each of the others. A change in it will then affect all the circuits alike.

The wiring is done on a plan devised by the consulting engineer of the plant, Mr. Charles H. Davis, of 120 Broadway, New York City, and known as the panel-board system. It is is believed that this plan, although the first cost is more than in the usual method, insures a minimum expenditure for repairs, ease in making changes or extensions, and an almost unlimited facility in operation. Panels of enameled slate, framed in antique oak, with plate-glass fronts, are placed in convenient places on the walls of the halls, corridors and various rooms of the building, there being 75 in all, ranging in size from one to sixteen square feet. These panels are fed by mains from the various switchboards, a single pair of mains usually supplying current to two or more panels. From the bus bars of these panel boards the wires are carried to the lamps, each outlet in the building having a separate branch circuit. All fuses are placed upon the panels, none whatever being located at the fixtures.

A separate and independent night circuit runs to every corridor and room in the building, supplying one light in each. Key sockets control these lights, distinguishing them from those on other circuits.

In wiring the building, it has been divided into seven sections, namely, main music hall, oratorio hall, lateral building, Fifty-sixth street building, administration building, roof story and halls. All these are controlled from the three switchboards, a separate circuit running to each floor, with independent hall and night circuits. To accomplish this division over 65 miles of wire and 25 miles of interior tubing were necessary. The wire used throughout the building is the Grimshaw "white core." No wire smaller than No. 14 is used, and each individual wire of every double conductor is of the standard insulation, the two being merely taped together. This same style of double conductor is used in all of the interior conduits. It is worthy of remark that in the entire installation there are only two wire splices, and those occur where a change in the specifications made it necessary. It will be seen that this absence of splices is due to the peculiar method of distribution by panel boards. The wires are run throughout the building on or rather between porcelain insulators, 10,000 of these being used in the installation. The details of the construction outside of the dynamo-room have been under the immediate supervision of Mr. William B. Martin, a gentleman who has had an extended experience with this class of work, and whose attention to the details is a sufficient guarantee of a thoroughly reliable



DYNAMO AND ENGINE ROOM OF THE ELECTRIC LIGHT PLANT OF NEW YORK CITY'S NEW MUSIC HALL.

and trustworthy installation. It may be mentioned that this is the second large plant in New York City in which Mr. Martin has superintended the construction, the other being the 4,000-light plant in the Stewart store, at Tenth street.

There are only 512 electroliers in the entire building, and these have 1,643 lamps attached; the remaining lights, with the exception of 202 silk-cord drops, are single lamps placed in the decorations. The fixtures were all furnished and put in place by the Edison General Electric Company. Frosted bulbs are used on all the lamps, so as to avoid any possible glare that there might be from so many lights. The tubing used in the building was furnished by the Interior Conduit and Insulation Company, of New York city.

In the main music hall there are 1,137 lamps placed in the decorations; 179 in the ceiling and the walls of the stage, 339 circling the boxes and the balconies, and 619 in the main ceiling. All lights placed in the ceiling are accessible from above and can easily be reached for renewal. Only two fixtures appear in the entire hall. In the distribution of these 1,100 lights 44 independent circuits are run. It will be evident to the observer in the auditorium that the main purpose that has been kept in mind in the arrangement of the lights is the production of an effect as near that of daylight as possible, the lamps themselves being made as unobtrusive as could well be done in so large an audience-room.

The electrical work was designed by the consulting engineer, Charles H. Davis, in connection with the architect, William B. Tuthill, under whose supervision the building was designed and erected. The contractors were Messrs. Curtis & Dean, of the New York isolated department of the Thomson-Houston Electric Company, of Boston, Mr. E. G. Gilbert acting as superintendent of construction.

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Chronological History of Electricity, Galvanism, Magnetism and the Telegraph, from B. C. 2637 to A. D. 1888.—Part I.*

BY P. F. MOTTELAY.

A. D. 1492.——Columbus, Colombo, Colon (Christopher), the discoverer of America, is the first to determine astronomically the position of a line of no magnetic variation (on which the needle points to the true north), the merit of which discovery has, by Livio Santo, been erroneously attributed to Sebastian Cabot.

Columbus did not, as many imagine, make the first observations of the existence of magnetic variation, for this is set down upon the charts of Andrea Bianco, but he was the first who remarked, on the 13th of September, 1492, that "2½ degrees east of the Island of Corvo, in the Azores, the magnetic variation changed and passed from N. E. to N. W." Washington Irving thus explains the discovery ("Hist. . . . Ch. Columbus," Paris, 1829, vol. I., p. 198): "On the 13th of September, in the evening, being about two hundred leagues from the island of Ferro (the smallest of the Canaries), Columbus, for the first time, noticed the variation of the needle, a phenomenon which had never before been remarked. He perceived about nightfall that the needle, instead of pointing to the North Star, varied about half a point, or between five and six degrees, to the northwest, and still more on the following morning. Struck with this circumstance, he observed it attentively for three days and found that the variation increased as he advanced. He at first made no mention of this phenomenon, knowing how ready his people were to take alarm; but it soon attracted the attention of the pilot, and filled them with consternation. It seemed as if the laws of nature were changing as they advanced, and that they were entering into another world, subject to unknown influences (Las Casas, "Hist. Ind.," l. I., c. 6). They apprehended that the compass was about to lose its mysterious virtues; and, without that guide, what was to become of them in a vast and trackless ocean? Columbus tasked his science and ingenuity for reasons with which to allay their terrors. He told them that the direction of the needle was not to the polar star but to some fixed and invisible point. The variation, therefore, was not caused by any fallacy in the compass, but by the movement of the North Star itself, which like the other heavenly bodies, had its changes and revolutions, and every day described a circle round the pole. The high opinion that the pilots entertained of Columbus as a profound astromoner gave weight to his theory, and their alarm subsided."

De Humboldt says: "We can, with much certainty, fix upon three places in the *Atlantic line of no declination*, for the 13th of September, 1492, the 21st of May, 1496, and the 16th of August, 1498."

See "Cosmos," vol. I., p. 174, vol. II., p. 657, and vol. V., pp. 54, 116; Knight, "Mechanical Dictionary," vol. II., pp. 1,374, 1,397; Miller, "History Philosophically Illustrated," London, 1849, vol. II., pp. 216, 217; Poggendorff, "Geschichte der Physik," Leipsic, 1879, p. 270.

A. D. 1497.——Gama (Vasco or Vasquez de), celebrated Portuguese navigator, is known positively to have made use of the compass during the voyage he undertook this year to the Indies. He says that he found the pilots of the Indian Ocean making ready use of the magnet. The first book of the history of Portugal by Jerome Osorious says that, instead of a needle, they used a small magnetized iron plate, which was suspended like the needle of the Europeans, but which showed imperfectly the north.

See Azuni, p. 121; Klaproth, p. 64; also Knight, "Mechanical Dictionary," vol. II., p. 1,398.

A. D. 1497.——Cabot (Sebastian), a prominent English navigator, lands June 24, 1497, on the coast of Labrador, between 56 degrees and 58 degrees north latitude.

At page 150 of the 1869 London edition of Mr. J. F. Nicholl's Life of Seb. Cabot it is said the latter represented to the King of England that the variation of the compass was different in many places, and was "not absolutely regulated by distance from any particular meridian; that he could point to a spot of no variation, and that those whom he trained as seamen, as Chancellor and Stephen Burrough, were particularly attentive to this problem, noting it at one time thrice within a short space."

See "Examen Critique," De Humboldt, vol. IV., p. 231; Biddle, "Memoir," 1831, pp. 52–61; "Cosmos," vol. II., pp. 640 and 657.

A. D. 1502.——Varthema—Vestomannus (Ludovico di) leaves Europe for the Indies, as mentioned at page 25 of his "Travels," translated by J. Winter Jones, London, 1863, from the original "Itinerario. . . . ne la India . . . ," Milano, 1523. He states that the Arabs who navigated the Red Sea are known to have long since made use of the mariner's chart and compass, and he tells us, in the introduction and at page 249, that "the captains carried the compass with the needle after our manner," and that their chart was "marked with lines perpendicular and across." When the polar star became invisible, they all asked the captain by what he could then steer them, and "he showed us four or five stars, among which there was one (*B. Hydrus*) which he said was opposite to (*contrario della*) our North Star, and that he sailed by the north because the magnet was adjusted and subjected to our north (*i. e.*, because this compass was no doubt of European origin—its index pointing to the north, and being unlike that of the Chinese pointing to the south)."

See Cavallo, "Magnetism," London, 1787, chap. IV.

A. D. 1525–1530.——Guillen (Felipe), an ingenious apothecary of Seville, and Alonzo de Santa Cruz, one of the instructors of mathematics to young Charles V., King of Spain and Emperor of Germany, construct variation compasses by which solar altitudes can be taken. ("Cosmos," vol II., p. 658, and vol. V., p. 55).

A. D. 1543-1544.——Hartmann (Georg), a vicar of the Church of Saint Sebaldus, at Nuremberg, writes, March 4, to the Duke Albrecht of Prussia, a letter which was brought to light by Moser and which reads as follows: "Besides, I find also this in the magnet, that it not only turns from the north and deflects to the east about nine degrees, more or less, as I have reported, but it points downward. This may be proved as follows: I make a needle a finger long, which stands horizontally on a pointed pivot, so that it nowhere inclines towards the earth, but stands horizontal on both sides; but, as soon as I stroke one of the ends (with the loadstone), it matters not which end it be, then the needle no longer stands horizontal, but points downward (*fällt. unter sich*) some nine degrees, more or less. The reason why this happens I was not able to indicate to his Royal Majesty." The above seems to establish the fact that Hartmann first observed the dip of the magnetic needle independently of Robert Norman.

See Dove's *Reportorium der Physik*, II., 1838; "Encyl. Brit.," 1883, vol. XV., p. 221.

A. D. 1558–1589.——Porta (Giambattista della), Italian natural philosopher, carries on a series of experiments with the magnet, for the purpose of communicating intelligence at a distance. Of these experiments he gives an account in his (1589) "Magia Naturalis," the first edition of which was published at Naples when Porta was but fifteen years of age. ("Encyl. Brit.," art. "Optics.") Prof. Stanley Jones says this is the earliest work in which he has found allusions to a magnetic telegraph.

In the eighteenth chapter of Porta's book he describes the experiment of "putting a magnet under a table and moving thereby a needle above the table." This experiment, as Porta says, was known to Saint Augustine, and an exact description of it will be found in the "De Civitate Dei" (see the A. D. 426 date). It was likewise alluded to by Leonardus Camillus in his "Speculum Lapidum," published 1502. In the seventh book Porta thus expresses himself: "I do not fear that with a long-absent friend, even though he be confined by prison walls, we can communicate what we wish by means of two compass needles circumscribed with an alphabet."

A. D. 1575–1624.——Boehm—Böhme—Behmen (Jacob), a mystical German writer, known as the theosophist *par excellence*, is the author of "Aurora, etc." (1612); "De Tribus Principiis" (1619), and of many other treatises, which were reprinted under the title of "Theosophia Revelata," and which contain his many very curious observations concerning astrology, chemistry, theology, philosophy and electricity.

See "Notice sur J. Boehm," La Motte-Fouqué, 1831; *Notes and Queries* for July 28, 1855, p. 63; Ninth "Britannica," vol. III., p. 852.

A. D. 1576.——Norman (Robert), an ingenious artificer and a manufacturer of compass needles at Wapping, is the first who determined the dip or inclination of the magnetic needle in London by means of a dipping needle (inclinatorium) which he himself had devised. A few years later Norman publishes a pamphlet, "The Newe Attractive, showing the Nature, Propertie and manifold Vertues of the Loadstone, with the Declination of the Needle touched therewith, under the Plaine of the Horizon, ..." from which is taken the following: "Having made many and diverse compasses, and using alwaies to finish and end them before I touched the needle, I found continuallie that after I had touched the yrons with the stone, that presentlie the north point thereof woulde bend or decline downwards under the horizon in some quantitie; in so much that to the flie of the compass, which was before levell, I was still constrained to put some small piece of ware on the south point and make it equall againe. . . ."

In the fourth chapter of his work he describes the mode of making the particular instrument with which he was enabled to establish the first accurate measurement of the dip, "which for this citie of London I finde by exact observations to be 71 degrees 50 minutes."

For the means of determining the dip or inclination, see English Encyclopædia, "Arts and Sci.," vol. VIII., p. 160.

We have thus far learned that the *declination or variation* was first alluded to by Adsiger; that Norman was the first to determine the *dip or inclination*, and we shall, under the 1776 date, find that Borda determined the third magnetic element, called the *intensity*.

See *Nature*, XIII., p. 523; Walker, "Magnetism," p. 146; "Cosmos," vol. V, p. 57.

A. D. 1580.——The celebrated naturalist Li-tchi-tchin, who finished his *Pen-thsao-Kang-Mou* towards the end of 1580, says, "If the loadstone was not in love with iron it would not attract the latter." Eight and a half centuries before, about the year A. D. 727, the same allusion had been made by Tchin-Thsang-Khi in his "Natural History."

See Klaproth, "Lettre à Mr. De Humboldt . . ." Paris, 1834, p. 20.

A. D. 1580.——In Parke's translation of the "History of the Kingdom of China," written by Juan G. de Mendoza, a Spanish missionary sent to the Chinese Empire by Philip II., appears the following (vol. II., p. 36): "The Chinos doo gouerne their ships by a compasse deuided into twelue partes and doo vse no sea cardes, but a briefe description of Ruter (Ruttier, "Routier," direction book), wherewith they doo nauigate or saile."

A. D. 1581——Burroughs—Burrowes (Stephen), Comptroller of the English navy in the reign of Elizabeth, is the first in Europe to publish well authenticated observations upon the variation of the declination, deduced by him from actual observation while voyaging between the North Cape of Finmark and Vaigatch (Vaygates). These are recorded at length in his "Discourse on the variation of the Cumpas or Magneticall Needle," dedicated to "the travaillers, seamen and mariners of England."

At pages 7 and 8 of his "Terrestrial and Cosmical Magnetism," Cambridge, 1866, Walker gives extracts from the twelve chapters of Burroughs' work, which, "containing, as it does, the first recorded attempt at deducing the declination of the needle from accurate observations, must be considered as making an epoch in the history of terrestrial magnetism."

See Johnson, "New Univ. Encyl.," 1878, vol. III., p. 230, and the tables of the variations at pages 274, 275 of vol. II. of Cavallo's "Elem. of Nat. Phil.," 1825.

A. D. 1585.——Juan Jayme and Francisco Galli made a voyage from the Philippines to Acapulco for the sole purpose of testing, by a long trial in the South Sea, a declinatorium of Jayme's invention, from which De Humboldt says ("Cosmos," vol. V., p. 55) some idea may be formed of the interest excited in reference to terrestrial magnetism during the sixteenth century.

A. D. 1586.——Vigenere (Blaise de), in his annotations of Livy ("Les Cinq Premiers Livres de Tite-Live," Paris, 8vo, vol. I., Col. 1316), alludes to the possibility of communicating the contents of a letter through a thick stone wall by passing a loadstone over the corresponding letters circumscribing the compass needle.

See "Emporium of Arts and Sciences," vol. I., p. 302.

A. D. 1589.——Acosta (Joseph de), learned Jesuit, says in his masterly "Historia Natural de las Indias" (lib. I., cap. 17) that he is able to indicate four lines of no variation (instead of one only, discovered by Columbus) dividing the entire surface of the earth: "foure poyntes in all the world, whereas the needle looked directly towards the north." De Humboldt remarks that "this may have had some influence on the theory advanced, in 1683, by Halley of four magnetic poles or points of convergence."

A. D. 1590.——Wright (Edward), English mathematician, writes a valuable "Treatise on Navigation" which is published by Prince Maurice, Lord High Admiral of the United Provinces, and in which is urged the advantage of keeping registers of the variations observed on all voyages. Thus, says Lardner, the variation of the variation, not only as to time, but as to place, had at this period begun to receive the attention of those engaged in navigation.

Wright constructed for Prince Henry a large sphere which represented the motion of the planets, moon, etc., and he predicted the eclipses for seventeen thousand one hundred years. He is said to have discovered the mode of constructing the chart which is known by the name of Mercator's Projection.

A. D. 1590.——Cæsar (Julius), a surgeon of Rimini, observes the conversion of iron into a magnet by position alone. This effect was noticed on a bar which had been

* Continued from The Electrical World, May 16, 1891.

used as a support to a piece of brickwork erected on the top of one of the towers of the Church of St. Augustin.

See Noad, "Man. of Elec.," London, 1859, p. 525; Gassendi, A. D. 1632.

A. D. 1597.——Barlowe (William), Archdeacon of Salisbury, publishes his "Navigators' Supply," from which the following is extracted: "Some fewe yeares since, it so fell out that I had severall conferences with two East Indians which were brought into England by Master Candish (Thomas Cavendish) and had learned our language. . . . . They shewed that in steade of our compas they (in the East Indies) use a magneticall needle of sixe ynches long . . . . upon a pinne in a dish of white *China* earth filled with water; in the bottome whereof they have two crosse lines for the foure principall windes, the rest of the divisions being reserved to the skill of their pilots."

Barlowe also wrote, 1616–1618, "Magneticall Aduertisements, or diuers pertinent obseruations and approued experiments concerning the natures and properties of the Load-stone, etc.," wherein he states that "That wonderfull propertie of the body of the whole earth called the magneticall vertue (most admirably founde out and as learnedly demonstrated by Doctor Gilbert, physitian vnto our late renowned soveraigne Queen Elizabeth of happy memory) is the very true fountaine of all magneticall knowledge. So that although certain properties of the load-stone were knowne before, yet all the reasons of those properties were vtterly vnknowne and never before revealed (as I take it) vnto the sonnes of man."

See Cavallo, "Magnetism," 1787, p. 46; also A. D. 1302.

A. D. 1599.——Pancirollus (Guido)—Panciroli (Gui)—already quoted at A. D. 121, further remarks: "The ancients sailed by the pole star, which they call *Cynosura*. . . . The compass is believed to have been found at Amalfi, about 300 years ago, by one Flavius. And this unknown fellow (if it was Flavius) hath deserved more than 10,000 Alexanders and as many Aristotles. . . . This single act hath improved knowledge and done more good to the world than all the niceties of the subtle schools."

See "History of Things Lost," London, 1715, vol. II., p. 328; also his biography, Larousse, "Dict. Univ.," vol. XII., p. 108, and "Dict. de Biog.," tome II., p. 2,012.

A. D. 1600.——Schwenter (Daniell), under the assumed name of Janus Herculus de Sunde, describes, in his "Steganologia et Steganographia," the means of communicating intelligence at a distance by means of two compass needles circumscribed with an alphabet, the needles being diamond shape, from the same piece of steel, and magnetized by the same (bar) magnets.

Under caption "The first idea of the electric telegraph," the following appeared in the *Journal of the Franklin Institute*, vol. 21, 1851, p. 202: "In the number of the *Philosophical Magazine* for May, 1850, I (N. S. Heineken) observe that Professor Maunoir claims, for his friend, Doctor Odier, the first idea of the electric telegraph. I herewith send you a translation of "How two people might communicate with each other at a distance by means of the magnetic needle," taken from a German work by Schwenter, entitled "Delicioe Physico-Mathematicæ," and published at Nürnberg in 1636. . . . upward of a century before the period alluded to by Professor Maunoir. Indeed, Oersted's grand discovery was alone wanting to perfect the telegraph in 1636. The idea, in fact, appears to have been entertained prior even to this date, for Schwenter himself quotes, at page 346, from a *previous* author. This "previous author" is either Giambattista della Porta, quoted at A. D. 1558–1589, or Famianus Strada, who appears herein under the A. D. 1617 date.

The passage from Dr. Louis Odier's letter relative to an electric telegraph will appear at A. D. 1773.

Differential Gear for Electric Elevators.

BY G. A. JUNGREN.

In a recent number of THE ELECTRICAL WORLD appeared a cut illustrating an arrangement of gears by which it was possible to obtain a great differential in angular speed. Shortly after the issue of this paper I was employed to construct a hoisting apparatus for elevators, operated by electricity and based upon this contrivance.

The result was a machine with two internal gears instead of central spur gears, and two smaller ones revolving in each of these rings.

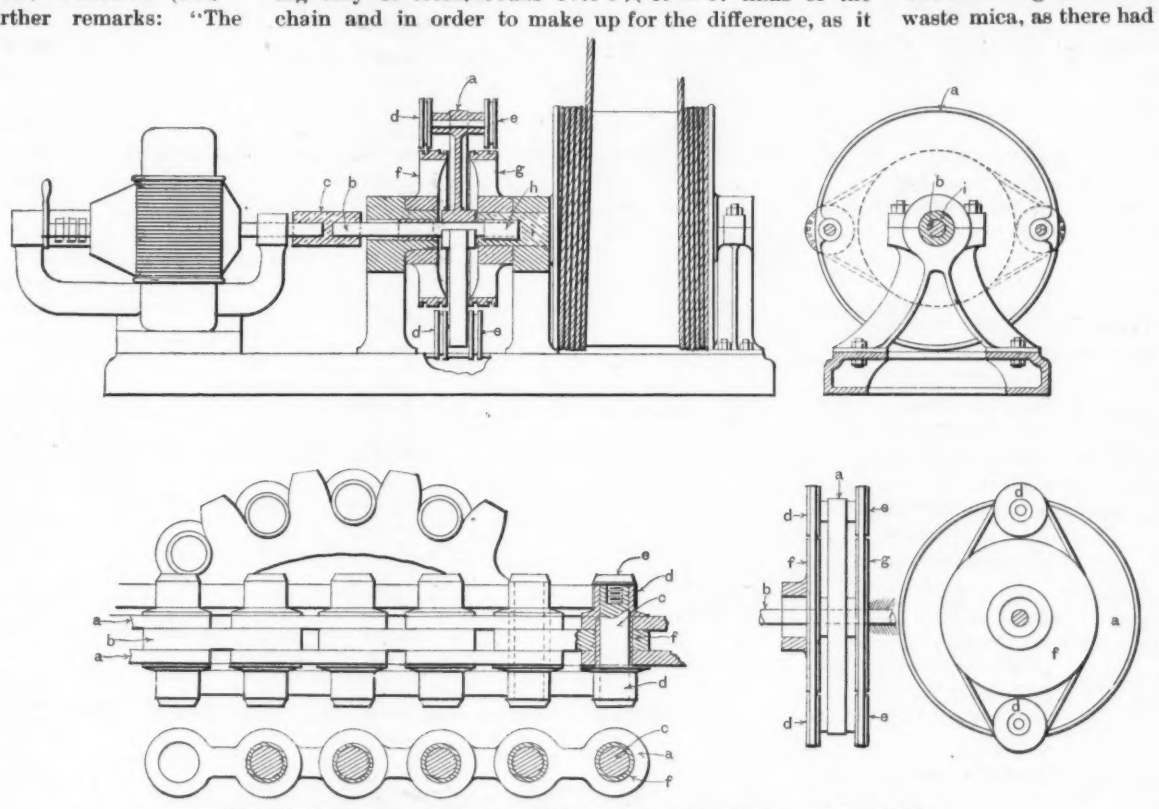
This seemed to me to be a fairly good arrangement for an elevator, as a good deal of the friction is obviated as compared with screw devices and common gearing where the pinions and gears have to be of very large difference in size. Another advantage might be in the fact that it is almost impossible for the engineer to start or stop the car suddenly, because the four driving gears will act as a flywheel and prevent jerks.

Still, gears are rather objectionable considering the high speed, for steel gears, even nicely cut, will make noise after some time, and rawhide pinions would be too expensive, as they are not very durable. To overcome this obstacle I have devised the apparatus here described. In the accompanying cut *a* represents a wheel fastened to a shaft *b*, directly connected with the motor by a coupling *c*, the object of which is to prevent magnetizing of the whole machinery.

This wheel carries journal bushings for two little shafts, each one holding two sprocket pinions *d d* and *e e* tightly keyed on them.

These pinions are connected with the two sprocket wheels *f* and *g*, through four chains, described below; *f* is firmly fixed to the foundation and *g* is keyed to the drum shaft. The driving shaft *b* is supported by two bearings, one of which, *h*, is formed by the drum shaft, in which *b* ends, having a bushing of some compound metal driven on it. Now, as the armature of the motor turns round once the sprocket wheel *d* travels over as many links of the chain as there are sprockets on the large wheel *f*. Let this number be 60, and let *d d* have 20, *g* 60 and *e e* 19.

Accordingly *d* revolves $\frac{60}{20} = 3$ times. The wheel *e* being on the same shaft must have the same motion, but, having only 19 teeth, it runs over $3 \times 19 = 57$ links of the chain and in order to make up for the difference, as it



JUNGREN'S DIFFERENTIAL GEAR FOR ELECTRIC ELEVATORS.

were,—which is $60 - 57 = 3$ sprockets,—the wheel *g* attached to the drum shaft is moved $\frac{3}{60}$ of a revolution, or the differential is 1 to 20.

The figure also shows a device where only two chains are used, which makes the whole arrangement more desirable: but it has to be decided by experiment, as the tendency of the chain to assume circular form at high speed will cause it to slip over the sprockets of the two central wheels.

A couple of brakeshoes placed diametrically, or a steel band applied on the ring of wheel *a*, will make an excellent brake arrangement, which of course ought to be operated by electricity.

Of course I had to construct a chain that would answer the purpose for this work, as so far as I know there was none in existence. It had to be strong and light, durable and practically noiseless. The description below will enable one to judge how far I have succeeded.

The main principle in this chain was known long ago and is well understood. The straining parts of it—that is, the links *a b* and the rods *c*—are made of steel of as high grade as practicable with cost, to get it as light as possible. Sprocket wheels out of steel will probably add a good deal to the neatness of the whole.

I have made the addition of the little caps *d*, slipped over the ends, and the bushes over the middle of the rods. These little caps, which prevent the steel parts of the chain from touching the sprockets, are made of rawhide or any other material that will deaden the noise and at the same time be durable. They are held in position by the screw *e*. The bushes that transmit the pressure between the links and rods are meant to be made of some hard compound anti-friction metal.

I devised this chain or link belt originally only for the above-mentioned hoisting apparatus, but, if it really has the advantages that I now see in it over the known ways to transmit power, its application will be very extensive.

Let us compare a common rawhide pinion running together with a steel gear, as is the case with street cars, and two sprocket wheels connected together through a chain, like the one described above.

When put in at first there is no great accuracy required in the distance between centres of the sprocket wheels, as is the case with the gears; by having one bearing adjustable, the chain can always be kept sufficiently tightened.

With the chain all the wear is practically reduced to the caps and bushes, which easily may be replaced at short notice and at comparatively little cost; and thus by rebuilding your chain, as it were, you can secure a smooth run, something very difficult with gears, where they have been running for a while.

If the proportions in strength between the sprockets and the rods of the chain are made so that in case of accident the breakdown always will be on the chain, it is easily repaired if some extra links are kept on hand.

The U. S. Census Report of the Mica Industry.

The production of cut mica in the United States in 1889 amounted to 49,500 pounds, valued at $50,000. In addition to this, 196 tons of scrap or waste mica were sold for grinding purposes, with a value of $2,450. The production in 1880, as given in the tenth census report, was 81,669 pounds of cut mica, valued at $127,825.

A review of the annual production during the past nine years shows that the industry advanced in importance until 1885. Since then the tendency has been downward, though the fluctuations in the production of the different regions have caused much irregularity in the annual totals. The following table does not include statistics of scrap and waste mica, as there had been no attempt prior to 1889 to determine the amount of this waste which has been utilized:

PRODUCTION OF CUT MICA.

Years.	Amount, lbs.	Value.
1880.....	81,669	$127,825
1881.....	100,000	250,000
1882.....	100,000	250,000
1883.....	114,000	285,000
1884.....	147,410	368,525
1885.....	92,000	161,000
1886.....	40,000	70,000
1887.....	70,000	142,250
1888.....	48,000	70,000
1889.....	49,500	50,000

Occurrence.—The localities in which mica occurs in an available form are not very numerous, and it is only in New Hampshire and North Carolina that the industry has assumed much importance. In the West the most important deposits are located in the Black Hills, in the neighborhood of Harteville, Wyo., and in the Cribbensville district of New Mexico.

Production.—The greater part of the product in 1889 was taken from one mine in New Hampshire. Of the North Carolina mines none were in steady operation throughout the year, and the production of that State was the result of irregular and spasmodic efforts. In Virginia the production was confined to one mine, located at Amelia Court House, which was exhausted early in the year. In the Black Hills region, where in 1884 eleven mines were operated, with a production of over 18,000 pounds of mica, only one produced in 1889, and that only a small amount. In New Mexico a good deal of development work was done and a quantity of good mica was reported as taken out; but as none of this was marketed it has not been included in the totals for 1889.

The statistics of the industry in 1889 are shown in the following table:

Distribution.	Production. Cut. Lbs.	Cut. Val.	Scrap. Short tons.	Scrap. Val.	Expenses. Total.	Expenses. Wages	Men employed.	Capital invested.
N. Hampshire.	40,000	$40,000	160	$2,000	$38,635	$28,330	70	$194,750
N. Carolina...	6,700	7,000	...	.....	12,722	7,266	63	438,475
Virginia.....	*2,800	3,000	*36	450	†4,728	†4,528	26	.....
South Dakota.							3	13,300
New Mexico...	.....	.....	..	.....	2,250	2,050	12	14,700
Other States..	.....	.....	...	.....	.....	.....	11	30,325
Total.....	49,500	50,000	196	$2,450	$58,335	$42,174	185	$691,550

*Combined in order that operations of individual establishments may not be disclosed.
†Including Massachusetts, Wyoming and Idaho.

The amount of manufactured mica imported into the United States since 1869 has been as follows:

Year.	Value.	Year.	Value.	Year.	Value.	Year.	Value.
1869.....	$1,165	1875.....	———	1880.....	$12,562	1885.....	$28,685
1870.....	226	1876.....	$569	1881.....	5,839	1886*.....	56,354
1871.....	1,460	1877.....	13,085	1882.....	5,175	1887.....	49,085
1872.....	1,002	1878.....	7,930	1883.....	9,884	1888.....	57,541
1873.....	498	1879	9,274	1884.....	28,284	1889.....	97,351
1874.....	1,204	.....	.....	.....	.....	.....	.....

* Calendar years from 1886 to 1889; previous years ending June 30,

Some Early Telegraph Correspondence.

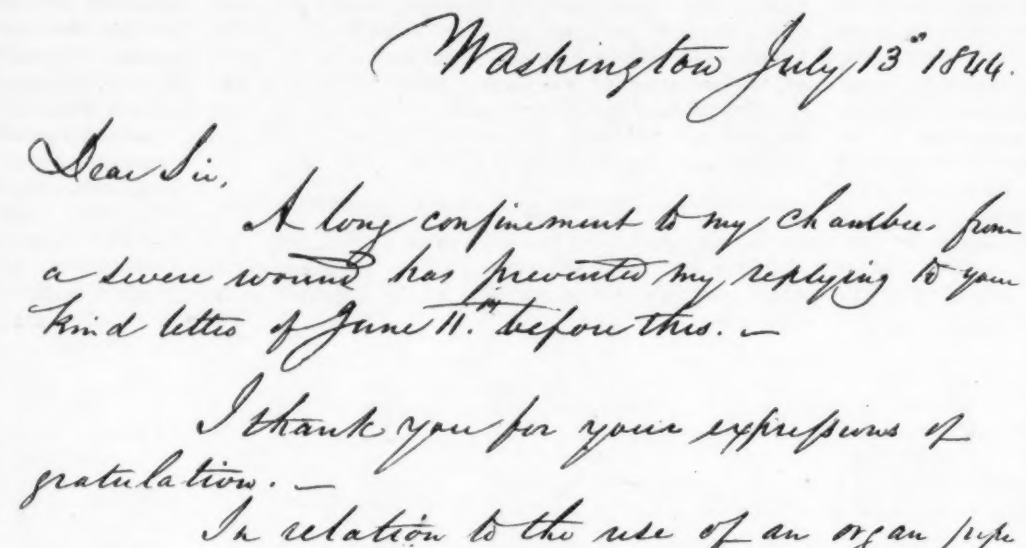
An interesting bit of the early correspondence of S. F. B. Morse relating to the reading of telegraph messages by sound is given in fac-simile on this page. The letter of Prof. Morse, which bears the date of July 13, 1844, was written in reply to a communication from the Hon. Elijah Paine, a prominent New York attorney, whose office at that time was in Wall street. It is of interest to note incidentally that Mr. Paine was, during the same period, one of the financial backers of Thomas Davenport and the owner of the English patents of the early Davenport motor.* The full text of Mr. Paine's letter, which is dated at New York, June 11, 1844, and in which attention is called to the possibilities of sound reading in telegraphy, is here given:

"My Dear Sir: Allow me to congratulate you on the entire success of your experiments, and on having connected your name with one of the greatest revolutions which has taken place on our planet. I have never seen your machine for writing down the news, but I believe I understand it, and I feel so much interested in it that I have puzzled myself about the difficulties, and, while thinking about these, an idea suggested itself to me which it is the object of this letter to communicate.

"Instead of writing down letters and using the eye, could you not do better with sound and the use of the ear? All that would be required would be sounds of different lengths—this could be effected by a single organ pipe, struck by a hammer—so long as the hammer was down the sound would continue. Now you can find those (and indeed any one by practice will become so) who can tell as accurately the length of different sounds representing letters as we can tell the length of marks, and I rather think more so. And besides you would find, I think, that the pipe and hammer would be less liable to accident from attrition, and then there would be the advantage of having the eyes to write while you read with your ears.

"Whatever you may do with it, my dear sir, and if you never improve upon it, this is enough to satisfy the ambition of any mortal. But I have no doubt you will add many improvements to it. I am puzzled and curious to know how you will contrive to send us news to New York and Philadelphia by the same wires, tapping them at Philadelphia, but of course not stopping—that would never do. You had better find this out as soon as possible if you have not yet, for depend upon it some one will."

From Prof. Morse's reply to the above suggestion it will be seen that he was in the habit, even at that time, of reading messages entirely by the sound of the instrument.



Washington July 13th 1844.

Dear Sir,

A long confinement to my chamber from a severe wound has prevented my replying to your kind letter of June 11th before this.—

I thank you for your expressions of gratulation.—

In relation to the use of an organ pipe for indicating by sound my letters, it would undoubtedly answer, as I have tried the same in principle, by the striking of two bells of different tones, and taking notice of the intervals. Indeed I now often read by the sound of the lever without seeing the instrument. I thank you for the suggestion and will take an early opportunity to put it in operation, and will also take pleasure in communicating to you the result.—

I hope to be in New York in a few days and shall be happy to see you.—

Very Respectfully
Yr Ob. Sert

E. Paine, Esq.

Sam'l F. B. Morse.

FAC-SIMILE OF A LETTER WRITTEN BY SAMUEL F. B. MORSE TO HON. ELIJAH PAINE IN REGARD TO THE READING OF TELEGRAPH MESSAGES BY SOUND.

Death of Wells W. Leggett.

On Thursday of last week the death of Wells W. Leggett occurred at his home, in Detroit, Mich. Mr. Leggett was born June 8, 1847, at Farmington, Trumbull county, O. At the outbreak of the war, in his 15th year, he joined the army and served for a time without commission upon the staff of his father, Major-General M. D. Leggett. He was appointed and commissioned by President Lincoln a captain and aide-de-camp, August 16, 1864. He served until the close of the war, when he was made an appointee-at-large to West Point Military Academy, which he entered in 1865, graduating in 1869.

Mr. Leggett did not re-enter the army but went into civil life, adopting the practice of patent law in 1872, at which time and for many years thereafter he was in partnership with his brother, with offices at Washington, D. C. His father resigned the office of United States Commissioner of Patents in 1875 and entered into partnership with his sons, establishing an office at Cleveland, O. Here he lived until 1879, when he removed to Detroit, establishing his law office in that city and entering actively into the organization and management of many of Detroit's business enterprises.

Aside from his professional work he acquired large business interests, nearly all of which are identified directly with the city's growth and prosperity. His pet schemes were the Brush Electric Light Company, the Star Iron Tower Company, of Fort Wayne, Ind.; the Kilby Engine Works at Cleveland, O., and the Malleable Iron Works and the Spiral Tube Works at Detroit. Besides these, Mr. Leggett had stock in numerous manufacturing enterprises of Detroit. He was president of the Brush company of Detroit, and the last document he ever signed was one making Clarence A. Black his proxy, with authority to vote President Leggett's stock in deciding upon the deal with the Fort Wayne Electric Company, a deal which was concluded the day Mr. Leggett died. He was interested in the Brush Electric Company, of Cleveland, up to the time of its consolidation with the Thomson-Houston company.

Report on the Electrical Transportation System of the New England Portelectric Company.

BY FRANKLIN L. POPE.

In accordance with the request made by you* through Prof. Dolbear, I have made an examination of the system and experimental plant of the New England Portelectric Company, with a view to an expression of my opinion in reference to the results which may reasonably be expected to be attained in the commercial operation of a plant of this character when constructed on a scale sufficiently extensive to fully develop the capabilities of the invention. To this end I have observed and studied the operation of the existing experimental plant at Dorchester, Mass.,† and have taken notes of the results attained by it in actual operation. It did not seem necessary, for the purposes of the present investigation, to undertake a series of refined tests and measurements. Such a procedure would have consumed considerable time, and have been attended with unnecessary expense, while it could not after all have materially affected the value of the conclusions at which I have arrived. The measurements which have been made, though in a certain sense rough, are, nevertheless, sufficiently accurate and trustworthy to justify and support the conclusions which will be drawn from them.

Description of the Experimental Plant.—The experimental plant at Dorchester comprises an endless track, elevated upon a wooden trestle a few feet above the ground, 2,784 feet in circuit, consisting of one tangent of 588 feet, and another of 576 feet, united at their ends by two curves, one of which is 924 feet long and 282.5 feet radius, and the other 696 feet long and 234.4 feet radius. The track in the first tangent of 588 feet is level, while in other portions of the circuit are grades rising to a maximum of 4½ per cent., or 227 feet per mile.

The track consists of an upper and a lower rail, formed of bar steel ¾ inch by ¼ inch, fastened by countersunk screws to stringers. The upper stringer is of wood, two inches square, and the lower also of wood, two inches broad by four inches deep. The upper rail is supported and braced at intervals of about three feet.

The carrier is virtually a hollow projectile of wrought iron, cylindrical in form, with ogival ends, the cylindrical portion being eight feet long and 10 inches in diameter, the length 12 feet over all, and the weight approximately 500 pounds. It has capacity to contain say 10,000 letters, weighing, perhaps, 175 pounds. It is provided with two flanged wheels above, and two underneath, all of which, being fitted with ball bearings, revolve with very slight friction.

The propelling power is derived from a series of hollow helices of insulated copper wire, each of which encircles the track and carrier. These are fixed along the permanent way at intervals measuring six feet from centre to centre. Each helix is composed of 630 turns of No. 14 copper wire, in five layers, weighing about 20 pounds, and having a resistance of about five ohms. A contact wheel, mounted upon the carrier and running in contact with the upper track rail (which is divided into sections, and utilized as an electric conductor), connects the several helices in succession with the source of electricity as the carrier moves foward upon the track.

The electric current is supplied by a dynamo having a maximum capacity of about 8,000 watts, or a little over 10 h. p., driven by a steam engine rated at 10 h. p.

Experimental Data.—Experiments were first made to determine the maximum speed of carrier which could be obtained from the appliances in use at the time of inspection. This was found to be 2,784 feet in 56.5 seconds, or 49.3 feet per second, equal to 33.5 miles per hour.

The consumption of electric current, or rate of electric work while the carrier was in motion, could not be determined with strict accuracy, owing to the irregularity of the current, which caused the meters to fluctuate, but was approximately 200 volts and 38 ampères, equal to 7,600 watts. It may be stated with sufficient accuracy as between 9 and 10 electric h. p.

The tractive power of the helix upon the carrier was measured by an improvised dynamometer, the indications being read from a spring balance. The maximum tractive effort with a current of 10 ampères was found to be 80 pounds. The electrical force producing this magnetic attraction was 6,300 ampère turns.

Experiments were made upon a section of level and straight track to determine the rate of acceleration, from which the average tractive force exerted by the helices upon the carrier while in motion may be deduced. The performance of the driving engine and dynamo were not very satisfactory upon this occasion: but, by combining the results of my own observations with the results of independent observations at different times, furnished by yourself and Prof. Dolbear, I think I may safely put the rate of acceleration as high as 4.5 feet per second. The force of traction required to produce this acceleration, with the carrier of 500 pounds' weight, is as follows:

500 ÷ 32.17 (acceleration of gravity) = 15.54 × 4.5 = 69.93 (say 70).

Efficiency of the Apparatus.—The rate of acceleration with a given tractive effort becomes less and less as the velocity increases, until it is balanced by the constantly increasing resistance, when the motion becomes practically uniform. A tractive effort of 70 pounds, exerted upon the carrier moving at the rate of 50 feet per second, requires the expenditure of 6.3 h. p., or 4,712 watts. As the average

* See The Electrical World, April 25, 1891.

* This report is addressed to Mr. J. T. Williams, president of the New England Portelectric Company.

† For illustrations and full description of the experimental plant at Dorchester, see The Electrical World, May 4, 1889, and Oct. 18, 1890.

electrical energy supplied appeared to represent something like 8,000 watts, the efficiency of the helices and carrier, considered as an electric motor, may be estimated at about 60 per cent., which figure agrees very well with other determinations of solenoid magnets.

Improvement of the System.—It is evident that in order to render the system of commercial value the speed of the carrier must be greatly increased beyond that which has been found to be attainable with the existing experimental plant. It remains to consider the practicability of accomplishing this without entailing an inordinate cost of either installation or working.

Several improvements tending to aid in the attainment of this result suggest themselves, as follows :

1. Increasing the electrical efficiency of the helices.

2. Reducing the mechanical resistance to the movement of the carrier.

3. Increasing the absolute amount of electrical energy supplied by the generators to the helices.

I will consider these points in order.

There is some loss of efficiency, but not a very large loss, due to the space permitted between the inner surface of the helices and the exterior of the carrier. This is largely an allowance made to facilitate the passing of curves, there being one of only 234 feet radius. I would not advise the adoption, on a commercial line, of curves of less than 1,000 feet radius, in which case the clearance might be considerably reduced, to the advantage of the electrical efficiency.

The principal loss in electrical efficiency, in my opinion, arises from the inductive currents set up in each helix, as the contact is broken after the passage of the carrier. This action not only wastes energy, but rapidly burns away the metal of the contact-wheels and rails.

It appears to me that this evil might be largely, if not wholly, obviated, by the expedient of breaking the circuit a little earlier than is now done, and simultaneously closing the circuit of the coil on itself, thus compelling the induction current to *do work* in propelling the carriage. I have taken the liberty to submit herewith a plan for effecting this. The objection to this arrangement is in the short circuiting of the dynamo for an instant at each break, but not necessarily for more than 0.002 second. I would strongly advise that this be tried.

It is very apparent that the principal obstacle to the attainment of high speed in the present plant is due to the excessive mechanical resistance, arising from the unevenness, and especially from the lack of rigidity of the track. The small radius of the curves also adds materially to the resistance. The amount of noise made by the carrier when running at its highest speed is sufficient evidence of this (for noise always means waste of power), but a consideration of the conditions brings out the fact very prominently.

The resistance of the air to a carrier of this form and dimensions at a speed of 50 feet per second is less than one pound, and may almost be neglected. Dr. Dudley has recently stated that on the best modern railroads the resistance of trains running at 50 to 60 miles per hour, a rate considerably higher than that of the carrier when observed by me, the total resistance to traction was only from 10 to 12 pounds per ton. Hence it would seem that it ought to be entirely practicable to reduce the total resistance opposing the movement of the carrier, at a speed of, say, 30 feet per second, down to something like five pounds, certainly not more than one-tenth of what it now is.

All experimental knowledge justifies the assumption, that with a track perfectly smooth and rigid, or as nearly so as the mechanical skill of the day is capable of producing, the resistance will not at the utmost increase in a ratio more rapid than that of the speed, in which case a speed of 150 miles per hour, or 220 feet per second, should only give a mechanical resistance of 9 pounds, to which must be added the atmospheric resistance, which, according to the accepted formula of Bashforth, would amount to 8.69 pounds in addition, or a total of, say, 18 pounds. To overcome this would require an electrical rate of work equal approximately to seven h. p.

$$18 \times 220 = 4{,}360 \text{ (foot-pounds)} \div 550 = 7 + \text{h.p.}$$

It would seem, therefore, with a proper track, that the tractive power of such helices as are now in use, when supplied with electric energy of no greater value than that now employed, should be sufficient to propel the carrier at the rate of 150 miles per hour.

Elements of Cost of Electrical Plant.—Upon the assumption, therefore, that the tractive power of the helices now in use will be sufficient, under favorable mechanical conditions, to propel the carrier at an average velocity of 150 miles per hour, the next question for consideration is the quantity and cost of the copper wire necessary for the purpose.

In the experimental plant the helices are composed of 630 turns of No. 14 insulated copper wire, and weigh approximately 20 pounds each. They are placed six feet apart from centre to centre. There are, therefore, 880 helices, and 17,600 pounds of insulated wire per mile in the helices, in addition to that in the main conductors.

I have given much consideration to the possibility of reducing the amount of copper required. The computation already made shows that an average tractive effort of seven h. p. is required to maintain a speed of 150 miles per hour, and this must necessarily, under all circumstances, be proportionate to the square of the ampère-turns. It follows from this that a certain number of *ampère-turns per mile* will be required in any case, wholly irrespective of the length of the intervals between the helices; they may be nearer together with less turns on each one, or farther apart with more turns on each one. From this, furthermore, follows the apparently singular circumstance, that the *weight of copper* required in each coil to do the required work *does not in the least depend upon the potential of the exciting current*, and hence cannot be diminished by increasing the potential. Economy in conducting material can only be effected by forcing as large a volume of current as practicable to pass per unit of cross-section of copper.

As each coil is ordinarily in circuit for only a fraction of a second at a time, it is evident that a volume of current per unit of sectional area may be used with impunity in this case which would be wholly inadmissible under ordinary conditions.

In order to determine this point, experiments have been made with insulated copper wires under different conditions of current. It was found, as a result of a number of trials, that a copper wire having a textile insulation, when coiled into a helix of several layers, requires a cross-section of about 50 circular mils per ampère, in order not to carbonize the insulation after 15 to 20 seconds' time.

The present coil is of No. 14 wire, which has an area of 4,107 circular mils; this multiplied by the number of convolutions (630) gives a total sectional area of copper of 2,587,410 circular mils.

The helices and current used in the experimental plant may be taken as equal to 25,000 ampère-turns per helix. The magnetizing effect of this is equivalent to that of 25,000 ampères traversing a single turn. Therefore the proposed coil must have an aggregate cross-section of at least 1,250,000 circular mils. It would seem practicable, therefore, to reduce the weight of copper in the helices in the proportion of 2,587,410 to 1,250,000, that is, from 17,600 to about 8,500 pounds per statute mile of track.

In this connection a suggestion is offered which may be of value. It is known to be entirely practicable to construct helices from naked copper wire of any required thickness, wound in the helix by machinery so as to leave an insulating air space between the convolutions, and it is recommended that experiments be made with a coil of this kind having its layers separated by asbestos paper or mica. With such a coil it is reasonable to expect that the volume of current per unit of cross-section could be carried considerably beyond the point which has been assumed, with a corresponding gain in economy of copper.

A No. 4 wire having an area of 41,742 circular mils will deliver a current of 7.1 ampères, at a distance of 20 miles or 105,600 feet, with a drop in potential of 500 volts. If the initial potential is 1,500, and at terminals of the most distant coil 1,000, the mean loss of energy in the line between the initial point and the extreme end will be 25 per cent.

A No. 4 wire (double) weighs 1,332 pounds per mile.

This will make the total cost of copper wire for line and coils about as follows :

1,330 pounds copper for line, at 16 cents	$212.80
8,500 " " coils, at 23 "	1,955.00
Per mile of single track	$2,167.80

The provision for power required to propel the carrier at the assumed rate may be taken at 1,500 volts and seven ampères per 40 miles of single track, or about 0.33 h. p. of *generating capacity* per mile. This may be estimated, including steam plant and buildings, at $125 per h. p., or, say, $45 per mile.

So many considerations enter into the question of the total cost of a commercial line which are dependent upon the frequency with which carriers are to be sent—whether a double track will be necessary on any portion or the whole of the route, and many other like considerations—that I am unable to venture even upon an approximate estimate. I have, however, furnished the best attainable data from which this may be computed.

The question of the most economical interval between the stations is a very important one. I have assumed 40 miles, which I believe to be entirely practicable. It may be found feasible and economical to materially increase this interval. It is a question which is solely influenced by the potential which it is found practicable to employ.

The actual cost of the electric power required to propel the carrier at the assumed rate of 150 miles per hour may fairly be taken at five cents per h. p. hour, including cost of attendance at stations. The mere cost *of power* for propelling a carrier from Boston to New York would therefore not exceed 75 cents per trip.

General Conclusions.—The results of this investigation have convinced me that efforts for increasing the efficiency and economy of the Portelectric system should henceforth be directed mainly to the improvement of the track. The electrical portion of the system as exhibited in the experimental plant is judiciously planned, and I can suggest no material improvement other than those hereinbefore alluded to, viz., the short-circuiting of the coils and the use of naked wire and asbestos in the coils.

The opinion has recently been publicly expressed by an electrical engineer of reputation and experience that no automatic system of high-speed service for either passengers, freight or mail can ever come to a commercial issue. No arguments were adduced in support of this dictum, and, for my own part, I am wholly unable to see any good reason why this assertion should have been made in such an unqualified and authoritative manner. The experiments conducted under my direction at Dorchester are, in my own opinion, sufficient to prove the contrary. There can be no question but that a carrier can be automatically started and maintained at speed for any reasonable distance and for any reasonable length of time; the only question is as to stopping it with facility and safety at desired points. This may be effected, as was experimentally demonstrated at Dorchester several times in succession in my presence, by arranging a number of the ordinary propelling coils so that their successive tractive effort is exerted upon the carrier in the reverse direction, producing an exceedingly powerful retarding effort by the most invisible and gentle means. By this means a carrier traveling at the rate of 150 miles per hour may readily be brought to a stand without shock, jar or strain within a few hundred feet. Such an apparatus may be arranged at any point on the line, at an inconsiderable expense, and used or not as desired.

A straight track of 3,000 or 4,000 feet, provided with arrangements to stop the carrier by magnetic attraction, would, in my opinion, enable every question as to the capabilities of the system to be thoroughly determined by actual experiment. I see no reason why the speed should necessarily be limited to 150 miles per hour, but have taken that speed as one which is high enough to be of great commercial value, and yet low enough to be susceptible of having its conditions calculated from known experimental data. That this speed can be attained with a carrier of the dimensions of that now in use in the experimental plant, with not more than half the weight of copper per mile there used, and with no greater expenditure of power per mile run, I have every reason to feel confident, from the considerations which have been adduced.

The Measurement of the Power Given by Any Electric Current to Any Circuit.*

BY PROF. W. E. AYRTON AND W. E. SUMPNER.

IV.

THE BEST VALUE TO GIVE TO THE NON-INDUCTIVE RESISTANCE.

In cases where great accuracy is required in the measurement of the power given to a circuit, it is important to consider what value should be given to the non-inductive resistance (Fig. 1), in order to reduce to a minimum any error that may arise from possible inaccuracies made in the three readings of the voltmeter, or on the graduation of its scale.

Since $$W = \frac{1}{2r}(V^2 - V_1^2 - V_2^2),$$

$$dW = \frac{1}{r}(V dV - V_1 dV_1 - V_2 dV_2),$$

where dV, dV_1, dV_2 are the errors made in the estimation of the three P. Ds.

Let $$dV = \pm eV$$
$$dV_1 = \pm eV_1$$
$$dV_2 = \pm eV_2,$$

where e is a small fraction, *i. e.*, let the errors be each the same small fraction of the correct value, then the probable value of $(dW)^2$ is $\frac{1}{r^2}(V^2e^2V^2 + V_1^2e^2V_1^2 + V_2^2e^2V_2^2)$,

so that $$\left(\frac{dW}{W}\right)^2 = 4e^2\,\frac{V^4 + V_1^4 + V_2^4}{(V^2 - V_1^2 - V_2)^2}. \qquad (7)$$

Let the non-inductive resistance have such a value that

$$V_2 = xV_1, \qquad (8)$$

V_2 being already defined, the square root of the mean square of the P. D. between its terminals, and V_1 the square root of the mean square of the P. D. between the terminals of the circuit the power given to which we desire to measure. Then we wish to find the value of x that will make $\frac{dW}{W}$ a minimum.

Let φ be the angle of lag between the current in the circuit ac and the P. D. at the terminals of ab (Fig. 1), then φ is the angle of lag between the P. D. at the terminals of ab and the P. D. at the terminals of bc. Hence, since

$$v = v_1 + v_2,$$

v, v_1 and v_2 being the instantaneous values of the P. Ds.,

$$V^2 = V_1^2 + V_2^2 + 2V_1V_2\cos\varphi. \qquad (9)$$

Eliminating V, V_1 and V_2 by means of equations (7), (8) and (9), we have

$$\left(\frac{dW}{W}\right)^2 = 4e^2\,\frac{(1 + x^2 + 2x\cos\varphi)^2 + 1 + x^4}{4x^2\cos^2\varphi}.$$

Now, cos φ depends on the circuit, the power given to which we desire to measure, and is independent of x. Hence differentiating with respect to x and equating to naught in the usual manner, we find that x equal to unity makes $\frac{dW}{W}$ a minimum.

Hence, inaccuracies in the three readings of the voltmeter, or in the graduation of its scale, produce the least effect in this method of measuring power when the P. D. between the terminals of the non-inductive resistance is equal to the P. D. at the terminals of the circuit under test.

The next point to consider is, What is the percentage error made in measuring the power by this method com-

* Concluded from THE ELECTRICAL WORLD, May 2, 1891

pared with the percentage error made in reading one of the P. Ds.?

Let x equal unity, then

$$\frac{dW}{W} = 2e\,\frac{\sqrt{2 + 4\,(1 + \cos\varphi)^2}}{2\cos\varphi},$$

$$\frac{dW}{We} = \frac{\sqrt{2 + 4\,(1 + \cos\varphi)^2}}{\cos\varphi}.$$

Now, dW / We is the ratio of the percentage error made in measuring the power to the percentage error made in measuring one of the P. Ds. and the right-hand side of the last equation we find equals from 4 to 5 for the values of the lag angle φ that occur in ordinary practice. If, then, there were a positive or a negative error of 1 per cent. in each of the measurements of V, V_1 and V_2, there would be a probable error of from 4 to 5 per cent. in the measurement of the power. The probable percentage error in the measurement of the power being from 4 to 5 times the error in the measurement of each of the P. Ds. arises partly from the fact that the expression for W, being

$$\frac{1}{2r}\,(V^2 - V^2{}_1 - V_2)^2,$$

depends directly on the difference in the mean squares of the P. Ds., and not on the difference of the square roots of the mean squares. And all instruments that are graduated for measuring the square root of the mean square of an alternating P. D., such as a hot-wire voltmeter, an electrostatic voltmeter, etc., really measure the mean square and not the square root of the mean square directly; it would be better if such an instrument were to be employed for the method of measuring power described in this paper, that it should be graduated in mean squares of P. Ds. and not in the square roots of the mean squares. In that case, a similar line of reasoning to that employed above shows that the probable percentage error in the measurement of power by the method would be from 2 to 2.5 times the error in the measurement of each of the P. Ds.

It is, of course, clear that these errors to which we have been referring are not errors in any way essential to the method proposed for measuring power, since, by the employment of an accurately graduated voltmeter, by exercising care in taking the readings, and, if necessary, by repeating the measurements two or three times and taking the means of the observations, the power can be measured to any degree of accuracy desired.

V.

APPROXIMATE CALCULATION OF THE POWER FROM THE THREE READINGS OF THE VOLTMETER.

The calculation of the power from formula (1) is easy, especially when the voltmeter is graduated to read the mean squares of the P. Ds., and not the square roots of the mean squares. If, however, as is usually the case, the scale is graduated in square roots, then even the trouble of taking the squares may be saved, when $V_1 + V_2$ does not differ much from V, by using the following method:

Let the inductive resistance be arranged so that V_1 is nearly equal to V_2, and let

$$V_1 + V_2 - V = yV_1;$$

then, since $$\cos\varphi = \frac{V^2 - V_1{}^2 - V_2{}^2}{2\,V_1V_2},$$

we have, by making V_1 equal to V_2 and eliminating V, V_1 and V_2 from the last two equations,

$$1 - \cos\varphi = 2y\left(1 - \frac{y}{4}\right).$$

Now, the power that would be given to ab (Fig. 1) if there were no lag, or the apparent power, as it may be called, would be

$$\frac{V_1V^2}{r},$$

whereas the power that is actually given to ab is

$$\frac{V_1V_2}{r}\cos\varphi.$$

Hence,

$$\frac{\text{the apparent power} - \text{the true power}}{\text{the apparent power}} = 1 - \cos\varphi$$

$$\text{“} \quad \text{“} \quad \text{“} = 2y\left(1 - \frac{y}{4}\right)$$

$$\text{“} \quad \text{“} \quad \text{“} = 2y \text{ approximately if the lag be not very large.}$$

For example, suppose V_1 or V_2 were 50 volts, and V were 98 volts, then y, or

$$\frac{V_1 + V_2 - V}{V_1},$$

would be 4 per cent. Hence the true power would be 8 per cent. less than the apparent power. Or, in other words, to find the true power given to ab (Fig. 1), we should merely have to diminish $\frac{V_1V_2}{r}$ by 8 per cent. and the answer would be obtained.

If r were unknown, and A, the square root of the mean square of the current, were measured instead, then to obtain the true power for the values of V_1, V and V given above, we should diminish V_1A, the apparent power, by 8 per cent.

We will finally consider what is the percentage error made in estimating the power by the method last described, compared with the percentage error made in taking the value of $V_1 + V_2 - V$.

Let us assume that, on account of errors in the readings of V_1, of V_2 and of V, or on account of inaccuracies on the graduation of the voltmeter, the value of $V_1 + V_2 - V$ is taken as half a volt greater than its true value, that is, that this expression is erroneously increased by 1 per cent. of V_1, if we assume V_1 to be 50 volts as above. Then y will also be increased by 1 per cent., and since the true power is obtained by subtracting from the apparent power $2y$ times the apparent power, it follows that the power measured in this way will be estimated as 2 per cent. too low if the combined error made in measuring $V_1 + V_2 - V$ be plus 1 per cent. of V_1.

MEASURING THE POWER GIVEN OUT BY AN ALTERNATE CURRENT DYNAMO.

In consequence of the trouble usually experienced in correctly measuring the power given to an inductive circuit, it is usual when measuring the power given out by an alternate current dynamo to use for the outside circuits various resistances, all of which are, as far as practicable, non-inductive. But as the construction of adjustable non-inductive high resistances that will take large currents is a troublesome matter, we suggest the following as a convenient method of overcoming the necessity of employing such a non-inductive circuit:

Let the circuit external to the dynamo be ac (Fig. 1), only a portion of which is non-inductive, then, if V_1, V_2 and V have the values already given them, it is easy to show that the power given to both the inductive and non-inductive portion of ac, that is to the whole circuit external to the dynamo, is

$$\frac{1}{2r}\,(V^2 - V_1{}^2 + V_2{}^2).$$

And we anticipate that, if only a small portion bc of the circuit be strictly non-inductive, this voltmeter method of measuring the power given out by an alternate current dynamo will give more accurate results than can be often obtained by assuming that a so-called non-inductive circuit is really non-inductive, and, therefore, that the apparent power is the true power.

The Magnetic Circuit of Transformers: Closed Versus Open.*

BY S. EVERSHED.

(65) The surface over each spherical end of the core will be $2\,\pi\,r^2$, and if to this is added the flat surface next to the coil cheek, we have $3\,\pi\,r^2$ as the surface of the equivalent sphere, and, x being the radius of the latter, $3\,\pi\,r^2 = 4\,\pi\,x^2$. Since $r = 13$ centimetres, x must be 11.3 centimetres, and the magnetic resistance of the air path is $\frac{1}{2\,\pi\,11.3} = \frac{1}{71}$. The total induction is $6{,}800 \times 40 = 272{,}000$ thoms, so that [H] required for the air path is $\frac{272{,}000}{71} = 3{,}840$. The maximum H for the core may be safely put at about 7 C. G. S. units, and [H] for the core will be $7 \times 73 = 510$. The total [H] is therefore $3{,}840 + 510 = 4{,}350$, which, divided by $.4\,\pi\,N$, gives the maximum value of the exciting current, or $C' = \frac{4{,}350}{1.26 \times 1{,}670} = 2.07$ ampères, and the effective value may be taken as $\frac{2.07}{\sqrt{2}} = 1.46$ ampères. The observed exciting current required to give 2,000 volts on the primary terminals at the frequency of 100 ~ is 1.35 ampères, or nearly eight per cent. less than the calculated value. This clearly shows that even in the apparently hopelessly complex case of spherical ends formed of radial wires the equivalent sphere, based on the assumption that the spherical end is solid without making deductions for ineffective surface, leads to a sufficiently close approximation to the true exciting current.

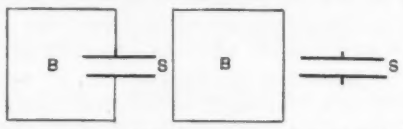


FIG. 22.—A SIMPLE CONDUCTING CIRCUIT OF NO RESISTANCE.

(66) To return from this digression on the calculation of exciting currents to the subject more immediately concerning us in these papers: the open transformer is a good thing so far as core waste goes, but there is the large exciting current still weighing like an incubus on our minds. Can it be induced to take some other path than the armature coils of the alternators at the supply station? This is not so difficult a problem as it seems at first sight. Think of electricity flowing along one main from the transformer to the alternator. If before it reaches the alternator it can escape into an elastic reservoir it will rush into the latter until the pressure from the mains is balanced by the elastic recoil. The reservoir being just so large that the elastic recoil pressure is at each instant equal to the main pressure, when the electric tide sets in in the opposite direction the electricity will be squeezed out again along the main toward the transformer, and not a drop will have been able to get beyond the reservoir to the alternator. Condensers are nothing more or less than elastic reservoirs, and Mr. Swinburne has been experimenting with them with a view to supplying idle current for his transformers. In order to understand their true function when used on alternate-current circuits, it will be necessary to devote a little space to the theory of condenser currents.

*Continued from THE ELECTRICAL WORLD, May 9, 1891.

(67) The discharge of condensers has been the subject of a great deal of attention for several years, and a recognition of its oscillatory nature under certain conditions (first explained by Sir William Thomson many years ago) has led to brilliant experimental verifications of the electromagnetic theory of light. It is probable that when once practical men who have to deal with electrical matters on an engineering basis have had it made clear to them what a condenser will do and why it does it, we shall see them taking up this, to them novel, apparatus and turning it to some practical account for electric light and power purposes. It has, of course, long been an indispensable adjunct in telegraphy.

(68) It is usual in discussing the laws of condenser currents to assume that the discharge takes place in a circuit having a resistance R and inductance L, and then determine what values must be given to R and L to make the current oscillatory, and when one is writing a mathematical essay that is no doubt the most interesting course to pursue. When the principal object in view is a clear explanation of the laws governing any complex phenomena, it is perhaps preferable to consider the simplest possible case first, and when that is made clear we may introduce the complicating conditions one at a time, and so arrive by easy and natural steps at the desired end—not necessarily the complete solution of the problem so dear to the heart of the mathematician, but a sufficiently clear conception of the general laws underlying the facts to enable us to make practical applications. That must always be the aim of the practical man who tries to grasp a theory, and he looks to the mathematical physicists to aid him in translating the dry bones of analytics into the flesh and blood of facts. But too often “the hungry sheep look up and are not fed”—hence we see practical men out of their depth in a sea of mathematics—hence these articles!

(69) To return to condensers. Imagine a simple conducting circuit of no resistance (Fig. 22). Suppose that at some time or other a current C was started in it. Some work was done in starting C—work stored in the surrounding medium as magnetic induction—but once having arrived at a steady value no more work is required and C will remain constant forever. The total induction threading the circuit under these conditions may be called B. Now, what will happen if we suddenly put the condenser S into the circuit? Will the current stop instantly? Evidently not, for the moment that it began to do so B would diminish, and so set up an electromotive force equal to $\frac{dB}{dt}$, driving the current on. If it does *not* stop it will begin charging the condenser and creating a potential difference between its terminals in a direction tending to stop itself. It will therefore decrease, and while decreasing there will be the corresponding decrease in B, acting as a forward electromotive force against the back electromotive force due to the charging of the condenser. But the current does not want either a forward or a back E. M. F.; there being no resistance, it needs exactly no E. M. F. Clearly, then, the current will diminish just sufficiently fast to allow $\frac{dB}{dt}$ to be exactly equal at every instant but opposite in direction to the growing potential difference V at the condenser terminals. Now V is equal to the ratio of the quantity of electricity stored in the condenser to its capacity K, or

$$V_t = -\frac{q_t}{K};$$

the minus sign is used because the charge would reverse the current if it could, and the current is considered to be positive. The E. M. F. due to the decreasing induction is $\frac{dB}{dt}$, and if we assume, for simplicity, that the magnetic medium is air or other non-magnetic substance, we know that B is directly proportional to C, so that we may write

$$B = L\,C,$$

where L is the induction due to unit current multiplied by the number of times it threads the circuit. L is usually called the coefficient of self-induction; it does not matter what it is called so long as it is clearly understood what it is. In the present case the induction is only linked once, there being only one turn of wire, so that L is simply the induction due to unit current.

(70) Now, $$\frac{dB}{dt} = L\frac{dC}{dt},$$

and this must at every instant exactly balance V;

therefore $$L\frac{dC}{dt} + V = 0. \qquad (1)$$

or $$L\frac{dC}{dt} = -\frac{q}{K}.$$

If this is differentiated with respect to t, we have

$$L\frac{d^2C}{dt^2} = -\frac{1}{K}\frac{dq}{dt} = -\frac{1}{K}C.$$

Each side may now be made a perfect differential by multiplying by $2\,\frac{dC}{dt}$; thus we have

$$2\,\frac{dC}{dt}\,\frac{d^2C}{dt^2} = -\frac{1}{LK}\,2\,C\,\frac{dC}{dt}.$$

Both sides being integrated, we arrive at

$$\left(\frac{dC}{dt}\right)^2 = -\frac{1}{LK}\,C^2 + A. \qquad (2)$$

A being the necessary constant of integration, the variables

c and t can now be separated, preparatory to the final integration, thus:

$$\frac{dC}{dt} = \frac{1}{\sqrt{LK}}\sqrt{ALK - C^2};$$

or

$$\frac{dC}{\sqrt{ALK - C^2}} = \frac{1}{\sqrt{LK}}\,dt.$$

The integral of the left-hand side is $\sin^{-1}\frac{C}{\sqrt{ALK}}$; so that

$$\sin^{-1}\frac{C}{\sqrt{ALK}} = \frac{t}{\sqrt{LK}} + \theta$$

and

$$C_t = \sqrt{ALK}\,\sin\left(\frac{t}{\sqrt{LK}} + \theta\right). \qquad (3)$$

(71) This may be simplified, for we reckon time from the instant when $q = 0$; that is to say, from the instant when the condenser was put into the circuit, and the current was then at its maximum, namely, C'. But the above sine function is at its maximum when $\frac{t}{\sqrt{LK}} + \theta = 90°$, so that $\theta = 90°$ since $t = 0$, and

$$C_0 = C' = \sqrt{ALK}\,\sin\theta = \sqrt{ALK};$$

also $\sin\left(\frac{t}{\sqrt{LK}} + \theta\right)$ is equal to $\cos\frac{t}{\sqrt{LK}}$, so that (3) is reduced to

$$C_t = C'\cos\frac{t}{\sqrt{LK}}. \qquad (4)$$

The current then varies according to a simple periodic law. When $t = 0$ the current is at its maximum, and when $\frac{t}{\sqrt{LK}} = \frac{\pi}{2}$ the current is zero; so that the value of t given by the equation

$$t = \frac{\pi}{2}\sqrt{LK}$$

corresponds with one-fourth of the complete period T; consequently

$$T = 2\pi\sqrt{LK},$$

or

$$F = \frac{1}{2\pi\sqrt{LK}}.$$

(72) The proof just given that the current becomes oscillatory when the condenser is inserted in the circuit has a somewhat fraudulent air of wisdom about it. It is either unreal or clumsy, according as it is seen from the point of view of the practical man or the mathematician. The latter may be referred to Sir W. Thomson's original paper on the subject, or to Dr. Fleming's exhaustive discussion of condenser discharge ("Alternate Current Transformer," vol. I., page 368). To the practical man we may be permitted to remark that the so-called solution of such a differential equation as (1) is in its very nature only guesswork, and the result is consequently no proof in the strict sense of the term. All we have really done is to find a function to express the relation between current and time, such that its rate of change at any instant is directly proportional to its integral from 0 up to that instant. For the electromotive force due to changing induction is proportional to the rate of change of current, and the potential difference at the condenser terminals is proportional to the quantity in it at any instant; that is, to the integral of the current. Now, in hunting for some function which fulfills this condition, we soon discover the cosine; its differential coefficient is a sine, its integral is a sine; therefore if the current varies according to the cosine of the time $\frac{dB}{dt}$ will vary directly as V; and consequently, by using proper constants, we can make the induction E. M. F. always equal to V. The proof, then, merely points to the cosine as a function which fulfills the conditions, but it does not tell us that it is the only one. However, having found a suitable function, the application of a little common-sense soon convinces us that it is the only possible one. The diagram given in Fig. 23 will serve as an aid to thought in arriving at orthodox convictions. The current C is shown as constant up to the time 0, when the condenser is put into the circuit. The current immediately falls off, and after a time $\frac{1}{4}T$ reaches zero. At first sight it might seem the more rational course for the current to remain zero; but imagine it to do so, and it is at once recognized that $\frac{dB}{dt}$ would immediately fall to zero also, leaving V to drive an *infinite* current back through the circuit, there being no resistance.

(73) Having thus started an alternating current in a condenser circuit, will it ever stop? Only a short time ago one would have said no, with a light heart. We are now, however, compelled to admit that the current waves do really produce radiation waves in the ether, or rather the two things are part and parcel of the same phenomenon. At all events light waves—very long ones—emanate from the circuit as a centre, and a little energy goes flying off into the uttermost parts of the universe, doing some good there, let us hope, but, so far as our circuit and condenser are concerned, the available store of energy put into the circuit when we started the current C is gradually frittered away, and becomes lost to us. Consequently the alternate current would slowly die away, even if the resistance of the circuit were really zero, as we have assumed.

(74) Fig. 23 shows that the oscillatory current in a condenser circuit is necessarily an idle current, and therefore exactly what is wanted to supply the idle part of the exciting current as an open transformer. But real circuits have a tangible resistance, and this leads to a rapid diminution of the amplitude of the current waves, unless we can devise a method by which the energy thus lost by the circuit may be continuously replaced by a fresh supply. Suppose the circuit in Fig. 22 has a finite resistance R, then we might imagine a magnet to be spun round anywhere in the circuit so than its induction threaded it alternately in reverse directions. If the magnet is rotated so that the impressed E. M. F. due to it has the same frequency as the current, and if we further arrange that its E. M. F. is cophasal with the current and at every instant exactly equal to CR (plus something very small for the power supplied to the universe as extra-double-infra-red-

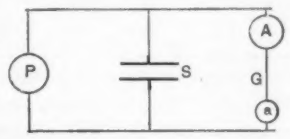


FIG. 24.—CONDENSER SHUNTED BY A BRANCH CIRCUIT.

light), the state of things shown in Fig. 23 becomes possible and stable, although it is not exactly what is wanted and does not represent what Mr. Swinburne is trying to achieve. Given a circuit and condenser like that in Fig. 22, can the necessary power be supplied in any other way? Yes. The condenser may be shunted by a branch circuit G (Fig. 24).

(75) The current will want to divide itself between P and G; and as it is all required to traverse P, which represents a transformer primary, we will have an alternator A in the G circuit running at the same frequency as the alternating condenser current in P, and impressing an E. M. F. cophasal with V and $\frac{dB}{dt}$, and of the same magnitude and shape. This will prevent any current flowing through A, so that the condenser current will alternate through P exactly as though the G circuit were absent. Now, let us put another alternator a into the G circuit, running at the same frequency, but a quarter period ahead of A, so as to have its E. M. F. cophasal with the alternating condenser current. The E. M. F. of the little alternator, being adjusted to the right value, will supply the C^2R loss in the transformer primary circuit P in precisely the same way as the spinning magnet was supposed to do. Of course, in practice the alternator A not only supplies the E required to keep the current out of G, but, by being run slightly out of step with the phase of V and $\frac{dB}{dt}$, it can be made to have a component E a quarter period ahead, and of the right value to provide for C^2R lost in P. All this sounds very alarming, but in reality

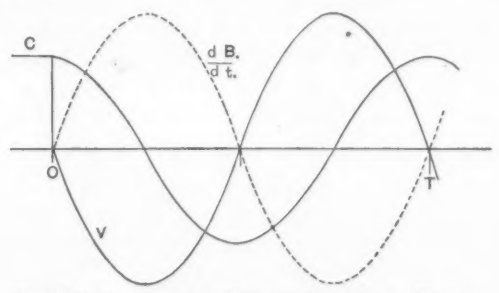


FIG. 23.—DIAGRAM OF ELECTROMOTIVE FORCES AND CURRENT IN THE CIRCUIT SHOWN IN FIG. 22.

C is the steady current. The condenser is put in the circuit at the epoch O. The full line V is the potential difference at the condenser terminals. The dotted line $\frac{dB}{dt}$ is the counter E. M. F. due to the changing induction in the circuit.

there are no adjustments. The condenser settles everything without human aid, for when connected across the mains it immediately monopolizes just so much of the idle current in P as will make its potential difference equal at every instant to that on the mains, and it is a simple matter to calculate what capacity the condenser ought to have to deal with the whole of the idle current in P, and no more. Of course, the switching on of the condenser tends to lighten the load on the alternator by the equivalent of the waste of power as C^2R in its armature coils due to the idle current. We say tends to lighten—it is by no means certain that condensers can be made to absorb no power, and the C^2R loss saved in the armature may possibly be balanced by a different kind of C^2R loss in the dielectric of the condenser.

(76) The condenser capacity required to supply an idle current of given value is readily found from the following considerations. Assume the idle current C is really sinoidal, so that

$$C = C'\cos\frac{2\pi}{T}t.$$

Suppose the system is working at an effective pressure E on the transformer primaries; then at the instant at which $C = 0$, that is when $t = \frac{T}{4}$, the potential difference between the mains is a maximum, and approximately equal to $\sqrt{2}E$. The quantity of electricity available for the condenser during the quarter period is

$$Q = \int_0^{\frac{T}{4}} C\,dt,$$

and the capacity of the condenser must be such that this quantity Q' raises V to exactly $\sqrt{2}E$; but

$$Q' = \int_0^{\frac{T}{4}} C\,dt = \int_0^{\frac{T}{4}} C'\cos\frac{2\pi}{T}\,t\,dt = C'\frac{T}{2\pi};$$

and therefore since $V' = \frac{Q'}{K}$,

$$V' = \frac{C'T}{2\pi K} = \sqrt{2}E;$$

or, remembering that $C' = \sqrt{2}C$,

$$K = \frac{CT}{2\pi E};\ \text{or}\ K = \frac{C}{2\pi EF},$$

an equation which gives the capacity K in farads when E and C are effective volts and ampères, and T is the periodic time in seconds, or F the frequency. But how if the idle current is not sinoidal? We have seen that in order to keep it out of the alternator it must follow a sine law, otherwise V cannot be made equal to E at each instant, and if these two variables are not always equal and opposite, some current will succeed in passing beyond the condenser terminals and traverse the armature of the alternator. If the current is not a simple sine function of the time, the condenser cannot possibly be made to take the whole of it; it will only absorb what may be called the sine component of the current, leaving all irregularities in the current wave —*ripples* as they are poetically called—to be supplied by the alternator. But for all practical purposes the formula just given is perfectly reliable, as only a comparatively rough guide is wanted to enable a condenser of suitable proportions to be made up, leaving the final adjustment until it is in actual use, when its capacity is readily varied until an ammeter in the main between the alternator and condenser indicates that the former is supplying the minimum current.

(77) A transformer circuit with a condenser across the mains presents the curious paradox of a complete metallic circuit in which the current is very much greater in one part than in the remainder. Perhaps it was this paradoxical behavior (first described by Mr. Blakesley) which directed Mr. Swinburne's attention to condensers. One is so accustomed to consider it an axiom that the total current flow at any instant is the same at every part of a complete conducting circuit, that the condition tacitly implied in the axiom, namely, that the circuit has no electrostatic capacity, is forgotten. To the eye of Maxwell, and perhaps also of Faraday, the condenser itself was just as much a part of the circuit as the wires themselves, and from this point of view there is nothing anomalous in a condenser circuit. Counting the condenser as a part of the circuit, the algebraic sum of the currents in the three branches P, S and G (Fig. 24) is at every instant exactly zero.

(To be continued.)

Notes on the Design of Multipolar Dynamos.*

BY W. B. ESSON.

In getting out the best relation L to d in the different types of armatures, it is assumed, of course, that, the volume being proportional to the diameter, the depth of the winding remains unaltered, as that is the condition which gives uniform rise in temperature. Accordingly, for a given output, the layer of copper on the armature will be of the same depth, whether the machine has two poles and an armature having a length of one and a half times its diameter, or four poles and an armature having a length of only half the diameter. But whether it is possible to reduce the gap to an extent which, with an increased number of poles, will lead to a less costly construction, is a question which, for machines of moderate dimensions, must receive careful consideration in each individual case. The answer depends upon how much larger the gap has to be to prevent sparking in the case of two poles only, than is requisite to accommodate the conductors and allow the necessary clearance. If the difference is considerable, it may pay better to add poles, and reduce the gaps that way, than to do the same thing by diminishing the pole angle or increasing the induction, or both. The question, it appears, is answered in different ways by different people. It is somewhat interesting to note, for instance, that one engineer, distinguished for the past six years as an ardent advocate of multipolar machines, has, after reducing from six poles to four, lately arrived at two, while another has jumped straight away from two to six without a halt at the intermediate number.

But when we come to machines of a certain size there is undoubtedly a gain in employing more than two poles, while very large machines become impossible of construction with two poles only. Consider the case of a two-pole armature of 60 centimetres diameter. Assuming the induction in the gap to be 5,000 C. G. S. lines per square centimetre, and the pole angle 130 degrees, our calculations show that the length of the gap would require to be 3.24 centimetres. This is some 40 per cent. in excess of the requirements of conductors and clearance; so, if the gap is reduced until it just allows of the requisite clearance,

* Concluded from THE ELECTRICAL WORLD, May 9, 1891.

the induction must be increased from 5,000 to 7,000. Keeping the output of the machine the same, however, we can reduce the diameter of the armature to 54 centimetres, and work with an induction in the gap of 6,500. Observe, the magnetizing force spent in the gap has now been reduced by about 7 per cent., but the total field through the armature has been increased by 15 per cent., and the induction in the armature per square centimetre by more than 25 per cent. If we retain the same section of iron in the fields, it may be assumed then that about the same total magnetizing force is required, whether the machine has an armature of 60 centimetres diameter, with a gap induction of 5,000 C. G. S. units, or one of 54 centimetres diameter, with a gap induction of 6,500. The latter might turn out to be impossible, owing to the greater heating of the armature core; anyway, what I am attempting to show now is, that by pressing up the induction with a view of reducing the gap, little, if any, advantage is ob-

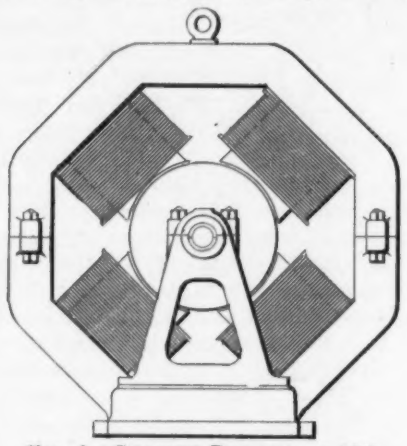


Fig. 6.—Gramme Dynamo of 1885.

tained. But by increasing the number of poles and reducing the gap in that way we effect, without increasing the gap induction, a marked economy. As it is unnecessary to go into a mass of figures to prove what each can readily prove for himself from the data already before you, I will just give here the results. If we substitute for the two-pole armature of 60 or 54 centimetres diameter and 90 centimetres long a four-pole one of 84 centimetres diameter and 45 centimetres long, with a gap induction of 5,000, we require for the magnetizing coils while working at the same sparking limit and with the same efficiency rather under 70 per cent. of the copper on the two-pole field. When to the saving in copper there is added the saving in iron, there will be, after the extra labor is debited against the four-pole machine, a considerable balance in its favor. But to go beyond four poles in this case would be a mistake. Increasing the poles always results in an actual increase of copper, unless at the same time the power spent in the gap is reduced, and this latter must be effected without reducing the thickness of the armature winding. The economy shown above is simply due to the fact that, in a two-pole machine of the dimensions specified, the gap necessary for the prevention of sparking must be much larger than the conductors require unless pressed up to a high induction.

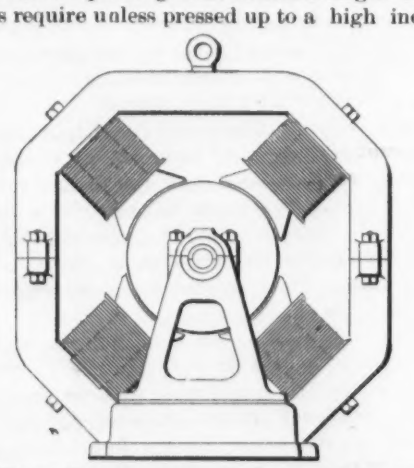


Fig. 7.—Kapp Dynamo with Wrought-Iron Magnet Cores.

If with four poles the gap is still larger than necessary, we go to six poles, and so on. But when we arrive at a point where increasing the number admits of no reduction in the gap, we go no farther. It may be mentioned, however, that even in sizes where a four-pole construction showed no actual economy in first cost, it might still be preferable to the two-pole on account of its symmetrical field and the absence of magnetic pull.

Having discussed the design of multipolar machines as influenced by both theory and practice, it remains to conclude this communication by calling attention to some of the ordinary forms of multipolar fields. The double wrought-iron horseshoe (Fig. 4) is not very frequently used, being rather costly; but a similar machine, with magnets of cast iron, lately made by my firm for the National Line steamship America, is shown in Fig. 5. The armature core in this case was formed by winding square annealed iron wires on a gun-metal flanged cylinder. The winding was of the Gramme type, and the machine was coupled direct to an inverted engine, as shown in the figure. This design, introduced by Gramme in 1869, generally gives place to the arrangement shown in Fig. 6, a form designed by the same inventor in 1885, and since adopted for cylinder-wound armatures by many makers, including Mr. Jaspar, in Belgium; Mr. Brown, of the Oerlikon Works, in Switzerland, and Messrs. Paterson and Cooper, in England. Lately Mr. Kapp has used the same form for six and eight-pole machines with drum armatures. The magnets and octagonal yoke in Fig. 6 are of cast iron, in two pieces, the lower limbs, the bottom half of the yoke ring and bedplate being one casting, and the top

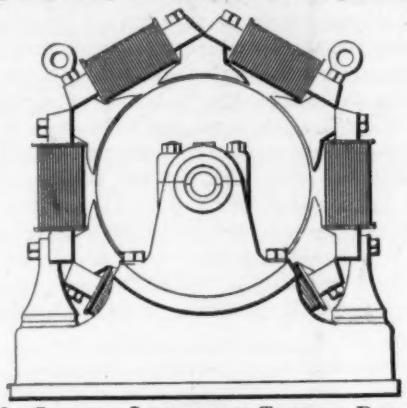


Fig. 8.—Sautter-Lemmonier Type of Dynamo.

limbs and upper part of the yoke being another. Fig. 7 represents a similar field in which the magnet cores are of wrought iron, fitted with cast-iron pole pieces, as used by Mr. Kapp in the machines above mentioned. The decision as to whether cast iron or wrought iron should be used is arrived at in a very simple manner—by comparing the excess of copper required on one hand with the extra machining required on the other.

It will be observed that in the designs Figs. 6 and 7 the yokes are considerably longer than those shown in Fig. 4;

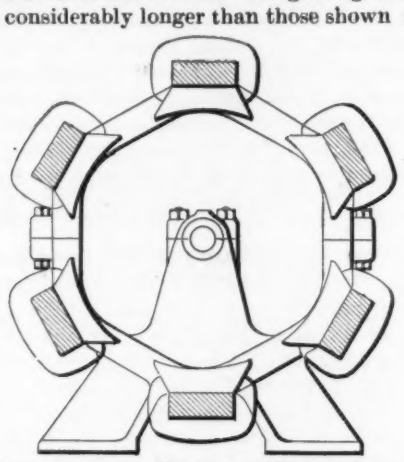


Fig. 9.—Dynamo with Magnets Composed of a Series of Wrought-Iron Bars.

and the weight of the former, if made of the same material, would be, roughly, twice that of the latter, though even then the complete magnet system would be but 75 per cent. of the weight of Fig. 3. The yokes being of cast iron, however, the system really comes about 20 per cent. heavier than Fig. 3, the less expensive character of the material compensating, of course, for the increased weight.

All these are examples of single magnetic circuits, where the lines of force from each pole remain undivided in their paths through the magnetizing coils; but in Figs. 8 and 9

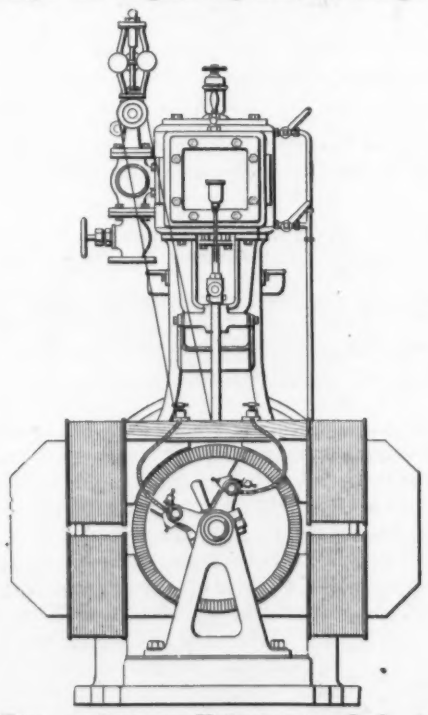


Fig. 5.—Type of Dynamo Used on the S. S. America.

are shown examples of double magnetic circuits, in which the lines from each pole take two paths through separate coils. Fig. 8 is a type of magnet used by Sautter-Lemmonier, of Paris, for Gramme-wound armature, and by Cuenod-Sautter, of Geneva, for armatures having a Siemens winding as modified by Thury. The magnetizing coils are wound upon the parts of the system constituting in Fig. 7 the yokes, and a greater amount of copper is in consequence required. It looks at first sight as if the weight of copper were not very different in the two types, but in this respect appearances are deceptive, for, as a matter of fact, the field of a four-pole machine made to Fig. 8 would require about 125 per cent. more copper than if made according to Fig. 7. It will be observed, however, that the magnet cores and pole pieces, which are made throughout of the softest wrought iron, are very light. In Fig. 9 the magnets are a series of wrought-iron bars lying parallel to the armature, each fitted with a cast pole piece in the middle of its length, and having two magnetizing coils, one on each side of this piece. It is a structure which may be frequently met with, though not precisely in the form shown, and the observations regarding the copper made with reference to Fig. 8 apply equally here.

The cost of a four-pole machine is approximately represented by the cost of a couple of two-pole machines of the same efficiency, which give each half the output at twice the speed; the cost of a six-pole by that of three two-pole machines, which give one-third of the output at three times the speed, and so on. For comparison, the fields must be in both the multipolar machines and two-pole machines of the same character—that is, with single or double magnetic circuits.

The fields of alternators may be similarly divided into those having single and those having double magnetic

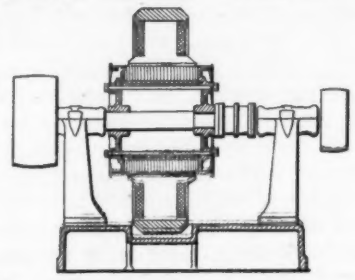


Fig. 10A.—Phœnix Alternator.

circuits; the former requiring, as in the fields of direct-current machines, much less copper than the latter. Among those having single magnetic circuits are the machines of Siemens, Ferranti, Mordey, Westinghouse, Elwell-Parker, and Paterson and Cooper. Mr. Kapp possesses the distinction of having the only alternator with double magnetic circuits. The "Phœnix" alternator, shown in Fig. 10, possesses some features which may be of interest as illustrating the way in which the commercial aspect of designing has to be considered. The yoke ring is of cast iron, but the magnets are of tooled wrought iron, shaped as shown. If the magnets had a breadth equal all the way up to the length of the armature core, they might as well have been of cast iron, for the little advantage consequent on the reduction of copper obtained by narrowing them would not have paid for the extra work in tooling wrought iron. But when we reduce the breadth where the magnetizing coils are, as shown, we at once diminish the copper on the fields by 60 per cent., greatly reduce the leakage area, and get a good balance after paying for extra tooling. The machine, as will be seen, has 12 radial magnets, and there are on the armature six flat coils, each equal to three times the width

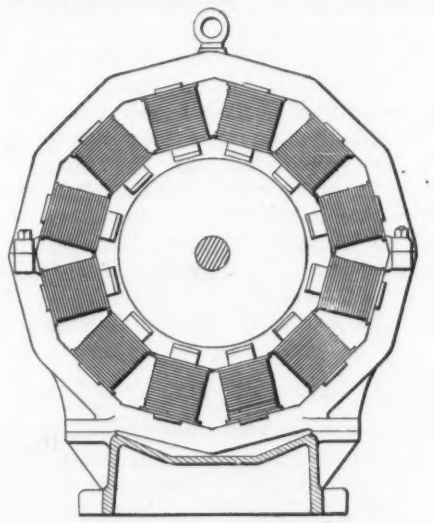


Fig. 10B.—Phœnix Alternator.

of the magnet cores, and laid on the periphery with a space equal to the core between them.

The length of the paper prohibits me from dealing with many special types of machine, to which, however, all the reasoning here used may be applied without difficulty.

A New Source of India Rubber.

In a paper recently published in the *Transactions of the Pharmaceutical Society*, Mr. E. M. Holmes, F. L. S., gives a description of an alleged "india rubber tree," which appears to be a native of China. The Chinese use bark called *Tu-chung*, which is highly valued by them as a medicinal agent, and a specimen of this was collected, among other Chinese drugs, by Dr. F. Porter Smith. In making a catalogue of this collection, this specimen attracted the attention of Mr. Holmes, who procured a fresh sample from Hong-Kong and examined it. When broken tranversely the bark exhibits a series of white, shining, silky fibres, which are very extensible; these are not spiral vessels, for the microscope showed no trace of these organs in the threads. On being placed in a flame a piece flared up and gave off the odor of burning india rubber. Prof. Oliver, the well-known authority at Kew, says the *Electrical Re-*

view (London), has examined this bark, and while unable to decide upon the systematic position of the tree from which it is derived, is very plain on one point, which is the only important consideration for electricians, namely, that a quantity of caoutchouc is present in the bark and in all the younger tissues, excepting the wood, properly so called.

On Some Effects of Alternating Current Flow in Circuits Having Capacity and Self-Induction.*

BY DR. J. A. FLEMING.

The full analytical treatment of the problem of the propagation of an electric current through a conductor possessing capacity and resistance is one which is by no means simple. If to this is added the consideration of the additional condition that both the line and the receiving and transmitting instruments possess self-induction, the problem in its full generality is a very complex one. For certain assumptions as to the mode of variation of the impressed electromotive force, and with other limitations, it may be said to have been solved for periodic currents; but, if we consider the practical case of receiving and transmitting appliances of variable inductance, it can hardly be said that analysis enables the results of definite arrangements to be completely predicted. Fortunately, in much practical work the additional complications which arise from the simultaneous presence of capacity and self-induction in the system are negligible, but useful, and existing work is not entirely thus limited; and electrical distribution by means of transformers, alternating currents, and concentric cables forces us to regard phenomena due to the co-existence of inductance resistance and capacity in one circuit, which need interpretation, even if only so far as to enable constructive mistakes to be avoided. We have already been made aware by experience that under these circumstances unexpected effects often make their appearance, and these demand examination at this period in the history of the large-scale manufacture and distribution of electric current, to enable us to appreciate the meaning of observed facts. The object of the present paper is to gather together some of the results already arrived at, and to point out a part of the existing state of knowledge of the propagation of alternating currents in circuits in which neither the inductance nor the capacity is so small that they can be left unconsidered in their effects.

2. It will be convenient to start the inquiry by examining a typical and simple case involving simple periodic electromotive force, and inductance and capacity in the circuit. Such problems have already been treated analytically by Dr. Hopkinson; geometrically by Mr. Blakesley, Major Cardew, Mr. Kapp, myself, and others.†

Let A be an alternator feeding an inductive current, $a\,b\,f$, of which the section $a\,b$ has inductance L and resistance R, and the section $b\,f$ has inductance l and resistance r. At b let a condenser of capacity C be inserted, and let the terminals e, d and f of the line condenser and alternator be to earth.

Let v_0 be the potential at a at any instant, and v_1 that at b; and let V_0, V_1 be the maximum values of these potentials, supposed to vary harmonically. Let i_1 and i_2 be the currents at any instant in the sections of the line, $a\,b$, $b\,f$, and i the current flowing into the condenser, and I_1, I_2, I the maximum of the same. Under these circumstances we proceed to investigate what are the relative values of V_0 and V_1, or their ratio to one another. We have always,

$$i_1 = i + i_2; \tag{1}$$

also,

$$i = C\frac{d\,v_1}{d\,t}, \tag{2}$$

and

$$l\frac{d\,i_2}{d\,t} + r\,i_2 = v_1, \tag{3}$$

but we may write, as the currents are simply periodic,

$$i_1 = I_1 \sin p\,t, \tag{4}$$

where $p = 2\,\pi\,n$, n being the frequency of the periodic current in $a\,b$, and t the time reckoned from the instant when the current in this first section is zero.

By elimination of v_1, i_1 and i from the above four equations we find easily that

$$C\,l\frac{d^2\,i_2}{d\,t^2} + C\,r\frac{d\,i_2}{d\,t} + i_2 = I_1 \sin p\,t. \tag{5}$$

Since i_2 must also be a simple periodic current, lagging in phase behind that of the current i_1, we may take i_2 to be of the form,

$$i_2 = I_2 \sin (p\,t - \theta). \tag{6}$$

Hence, by differentiation of (6), and substitution in (5), we arrive at

$$(1 - C\,L\,p^2)\,I_2 \sin (p\,t - \theta) + C\,r\,p^2\,I_2 \cos (p\,t - \theta) = I_1 \sin p\,t, \tag{7}$$

which, by a well-known transformation, may be put in the form

$$I_2\sqrt{(1 - C\,l\,p^2)^2 + C^2\,r^2\,p^2}\,\sin (p\,t - \theta + \Phi) = I_1 \sin p\,t. \tag{8}$$

Both sides of this equation (8) are expressions for the same thing—namely, the value of i_1—hence, equating coefficients, we have

$$\left(\frac{I_1}{I_2}\right)^2 = (1 - C\,l\,p^2)^2 + C^2\,r^2\,p^2. \tag{9}$$

Putting $a = 1 - C\,l\,p^2$, and $b = C\,r\,p$, we have,

$$\left(\frac{I_1}{I_2}\right)^2 = a^2 + b^2. \tag{10}$$

This gives us the ratio of the maximum, or square root of the mean square values, of the currents in the two sections of the line on either side of the condenser.

It is convenient next to shift the origin of the time, and take the instant when the current i_2 is zero as a point from which to reckon the time.

Doing this, we can write,

$$i_2 = I_2 \sin p\,t \tag{11}$$

and, accordingly, from (10),

$$i_1 = I_2\sqrt{a^2 + b^2}\,\sin (p\,t + \theta);$$

or

$$i_1 = I_2\,(a \sin p\,t + b \cos p\,t); \tag{12}$$

hence,

$$i_1 - i_2 = I_2(\sqrt{a - 1}\,\sin p\,t + b \cos p\,t), \tag{13}$$

but from (1) and (2)

$$i_1 - i_2 = C\frac{d\,v_1}{d\,t};$$

$$\therefore\ C\frac{d\,v_1}{d\,t} = I_2(\sqrt{a - 1}\,\sin p\,t + b \cos p\,t);$$

or

$$v_1 = \frac{I_2}{C\,p}(b \sin p\,t + \sqrt{1 - a}\,\cos p\,t); \tag{14}$$

$$\therefore\ V_1\frac{I_2}{C\,p}\sqrt{a - 1^2 + b^2} = I_2\sqrt{r_2 + p_2\,l_2}. \tag{15}$$

We have next to find the value of V_0.

$$v_0 - v_1 = L\frac{d\,i_1}{d\,t} + R\,i_1, \tag{16}$$

and if we substitute in (16) the value of i_1 given in (12), and of v_1 given in (14), and integrate, we arrive at

$$v_0 = I_2\left\{\left(R\,a + \frac{b}{C\,p} - L\,p\,b\right)\sin p\,t + \left(R\,b + \frac{1 - a}{C\,p} + L\,p\,a\right)\cos p\,t\right\}$$

but, since $\frac{b}{C\,p} = r$, and $\frac{1 - a}{C\,p} = p\,l$, we get by proper substitution in the above equation, and by the application of the rule for harmonic maxima, the equation,

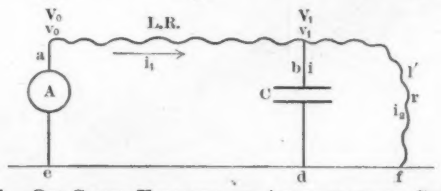


FIG. 1.—ON SOME EFFECTS OF ALTERNATING CURRENT FLOW.

$$V_0 = \frac{I_2}{C\,p}\sqrt{(A^2 + B^2)(a^2 + b^2) + 2\,B\,b - 2\,A\,a + 1}, \tag{17}$$

where

$$A = 1 - C\,L\,p^2; \qquad a = 1 - C\,l\,p^2;$$
$$B = C\,R\,p; \qquad b = C\,r\,p.$$

Equations (15) and (17) give us the values of the maximum or mean potentials at the generator and condenser end of the line $a\,b$. If we divide equation (17) by equation (15), we get a value for the ratio of V_0 to V_1. A little tedious process of division and substitution brings us finally to the required result, which is,

$$\frac{V_0}{V_1} = \sqrt{(A^2 + B^2) + (1 - C\,p^2)\frac{R^2 + p^2L^2}{r^2 + p^2l^2} + \frac{2\,L\,l\,p^2}{r^2 + p^2l^2} + \frac{2\,R\,r}{r^2 + p^2l^2}} \tag{18}$$

This last equation furnishes us with the required result, viz., the ratio of the maximum or mean potentials at the ends of the inductive line $a\,b$ in terms of the coefficients of inductance, capacity and resistance.

Given V_0, it enables us to calculate V_1, and to say whether V_1 is greater than, less than, or equal to V_0.

3. Let us examine some particular cases. Suppose $r^2 + p^2\,l^2 = \infty$ — that is, suppose the section of the line beyond the condenser removed—then

$$\frac{V_0}{V_1} = \sqrt{A^2 + B^2} = \sqrt{(1 - C\,L\,p^2)^2 + C^2R^2p_2} \tag{19}$$

This reduced case was treated by Dr. Hopkinson long ago,* and he showed, as we can easily see, that it is possible for the ratio of V_0 to V_1 to be *less* than unity—that is, for the potential at the receiving end, or at the condenser, to be *greater* than the potential at the sending end.

It is very easy to state the conditions under which this is the case. In order that V_1 shall be greater than V_0, or that there may be a rise of pressure, we must have

$$\sqrt{(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2}$$

less than unity; hence we must have

$$(1 - C\,L\,p^2)^2 + C^2\,R^2\,p^2 < 1,$$

or

$$1 + C^2\,L^2\,p^4 - 2\,C\,L\,p^2 < 1 - C^2\,R^2\,p^2,$$

or

$$C < \frac{2\,L}{R^2 + p^2\,L^2}. \tag{20}$$

If L, R and p are constant, the value of C, which makes the ratio of V_1 to V_0 a maximum, is

$$C = \frac{L}{R^2 + p^2L^2}.$$

Hence, if the capacity, C, of the condenser, measured in farads, is *less than* the quotient obtained by dividing twice the inductance of the line L, measured in henrys, by the square of the impedance $(R^2 + p^2L^2)$, we shall, under these circumstances, find a rise in pressure at the condenser end. For example, suppose the value of n or the frequency is 67, then $p = 421$, and $p^2 = 177{,}241$. If $R = 1$ ohm and $L = .1$ henry, then $R^2 + p^2\,L^2 = 1{,}773$, and there ought to be a rise in pressure if C is greater than 112 microfarads; or, if $R = 1$ ohm, and $L = 100$ henrys, then $R^2 + p^2\,L^2 = 1{,}772{,}410{,}000$, and there ought to be a rise in pressure if C is greater than one-eighth of a microfarad. Generally speaking, the greater L, the less will be the critical value of C. For high frequencies the criterion of rise of pressure at the condenser end is

$$C < \frac{2}{L\,p^2}.$$

That is to say, the critical capacity is just twice that which will at the given periodicity nullify the inductance of the armature circuit. It is worth while to note that even if the criterion for rise of pressure at the condenser end is fulfilled by L, R, C and p, yet, as seen from equation (18), a sufficiently small impedance $\left(\sqrt{r^2 + p^2\,l^2}\right)$ in the shunt may nullify the effect and force V_1 to be less than V_0.

4. These *condenser effects*, as they may be called, are very strikingly shown when currents of high efficiency are used. Quite recently Mr. Nikola Tesla has published some interesting observations and experiments on alternating currents with the very high frequencies of 10,000 to 20,000 alternations per second,* and among these he has described an experiment with a condenser joined across the poles of such an alternator. A machine was used giving about 20,000 alternations per second. Two bare wires about 20 feet in length were attached to the poles and their ends connected to the terminals of a condenser. The difference of potential between parallel points on these wires was explored by a voltmeter, and it was found that the potential difference of parallel points on the wires steadily rose inch by inch from 65 volts at the terminals of the alternator to 120 volts at the terminals of the condenser; and the writer states that observations on the self-induction of the armature in its position of maximum and minimum inductance showed that the capacity which gave the greatest rise at the condenser end corresponded apparently to that which would about nullify the mean self-induction calculated from the observed maximum and minimum. This entirely corresponds to the above theoretical deduction.

5. The fact that when a condenser is thus charged by an alternating current machine its terminal potential difference may be very much greater than that of the machine terminals, appears to have been noticed experimentally prior to the time when the simplest case was mathematically treated by Dr. Hopkinson. In the paper of the latter, above referred to, it is mentioned that Dr. Muirhead had observed it experimentally. In the discussion which followed Dr. Hopkinson's paper, Mr. Blakesley dealt with the same matter in some geometrical diagrams, and Prof. Ayrton mentioned that in 1878 or 1879 Mr. Munro took out a patent for the use of condensers in combination with an alternating current machine. In any case, the experimental verification of a rise of pressure along the line leading from the machine to the condenser is complete.

6. In his book on "Alternating Currents," p. 55 (second edition), Mr. Blakesley has treated, by his geometrical methods, the case examined above, with the object of showing that the employment of a condenser in this manner in combination with a pair of inductive circuits may, under certain conditions, cause the current in the remote, or shunt, circuit to be greater than the current in the circuit in connection with the machine; and he shows there that a similar criterion to the one given above applies also to the relative current strengths in the two sections, viz., that the current I_2 in section $b\,f$ will be greater than the current I_1 in section $a\,b$ if C is less than

$$\frac{2\,l}{r^2 + p^2\,l^2}.$$

Hence, generally, we have that the maximum or mean potential V_1 at the terminals of the condenser will be less than, equal to, or greater than the maximum or mean potential at the terminals of the machine V_0, according as the capacity C of the condenser is greater than, equal to, or less than the quantity $\frac{2L}{R^2 + p^2\,L^2}$ in numerical value; and also that the maximum or average current strength in the remote or shunt section of the line will be less than, equal to, or greater than the maximum or mean current strength in the section of the line near to the machine, according as the capacity, C, of the condenser is greater than, equal to, or less than the quantity, $\frac{2\,l}{r^2 + p^2\,l^2}$, in numerical value. Note that if R is measured in ohms and L in henrys, C must be measured in farads.

If we look again at the equation,

$$\left(\frac{V_0}{V_1}\right)^2 = (1 - C\,L\,p^2) + C^2\,R^2\,p^2,$$

and note what are the conditions under which V_1 will be *greater* than V_0, or the pressure at the condenser end greater than the pressure at the machine end of the line we see that it depends upon whether the right-hand expression, when worked out numerically, is a proper fraction. Since almost any capacity which occurs in practice is numerically represented by a very small fraction when the farad is the unit, if p^2 is not very great $C^2\,R^2\,p$ will nearly always in practice be a proper fraction when we insert

* Paper read before the Institution of Electrical Engineers (London).

† Dr. Hopkinson's Paper on "The Theory of Alternating Currents" is in the *Proceedings* of the Institution of Electrical Engineers (late *Journal* of the Society of Telegraph Engineers) for 1884, Vol. XIII., p. 496. Mr. Blakesley's papers are collected in his admirable little book on "Alternating Currents."

* See *Proceedings* of the Institution of Electrical Engineers for 1884, page 513.

* See THE ELECTRICAL WORLD, Feb. 14, 1891.

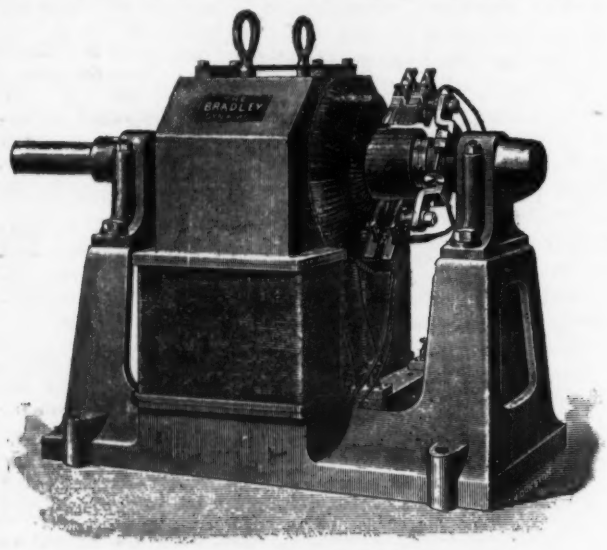
values of C and R in farads and ohms. Hence the condition of rise of pressure will depend almost always on whether $C\,L\,p^2$ is numerically greater than 2 when C and L are measured in farads and henrys; and if C is very small, either L or p must be very large to secure this result, and *vice versâ*. Hence, generally, if the inductance of the machine circuit is very large, a comparatively small capacity across its poles may give rise to a very great condenser effect; but if the inductance of the machine is small, a very large capacity will be needed to bring about the increased pressure at the terminals of the condenser.

Suppose, for instance, that a transformer is used to raise the pressure of an alternator, and that across the high pressure terminals of the transformer is placed a condenser of capacity C, this may be either a condenser of the ordinary form, or a certain length of concentric cable insulated at the far end and having a definite capacity. Let us suppose that the high-pressure circuit of the transformer has a great many turns of wire. The mean inductance of this high-pressure coil is then the L in our formula, its resistance is our R, and p^2 is $4\,\pi^2 n^2$, where n is the frequency of the alternator. To fix our ideas, let $n = 83 = 10{,}000$ alternations per minute, then $p^2 = 273{,}947$.

(*To be continued.*)

The Bradley Dynamo.

A new form of shunt-wound, slow-speed dynamo is just being placed on the market by the Phœnix Electric Manufacturing Company, of Massillon, O. The special features of the machine were designed by Mr. James Bradley, the vice-president, superintendent and electrician of the company, and have proved efficient and economical in every-day work for more than a year. The company is a strong one, and will proceed at once to manufacture dynamos, motors, railway generators, and especially incandescent lamps. A four-story brick building has been purchased, which is rapidly being equipped with the best forms of improved machinery and is expected to be in full operation at an early day. Already the company has secured orders for several dynamos, seven motors and one 80 h. p.



THE BRADLEY DYNAMO.

generator for railway work. Mr. Peter Sailer is president of the company; Mr. I. M. Taggart, treasurer; and Mr. James C. De Long, secretary.

The End of the New York Subway Controversy.

Final action was taken last week by the New York Board of Electrical Control in the contest which for years has been carried on between the opposing factions in the electrical world, represented on the one side by the combined electric lighting companies, and on the other by the Western Union Telegraph Company, the Metropolitan Telephone Company, the Edison Electric Company and the Bell Company, resulting in a complete victory for the latter combination, which, under the title of the Empire City Subway Company (Limited), was awarded a privilege which practically will give it full control of all the subways hereafter to be built. The high-tension electric light companies, with a capital of $15,000,000, had been compelled by the exigencies of the occasion to unite for the first time in their history, while their opponents, especially the Metropolitan and Edison companies, which already virtually own the old subway company, were equally determined.

Counsel Edward Lauterbach, Vice-President and General Manager Ridgway, Engineer Beckwith, Lawyer William N. Cohen and Secretary Sefton were present for the Consolidated Subway Company; President David R. Parker, of Boston, represented the Empire City Subway Company (Limited); Paul D. Cravath represented the Westinghouse systems; ex-Judge Kelly, the East River Company, and ex-Assistant District Attorney Foster, the Mount Morris Company. General Manager Browne, of the United Light and Power Company; General Manager Moore, of the East River Company; General Manager Leslie, of the Manhattan Company; President Cutler, of the Telephone Company, with Corporation Counsel Clark and Public Works Commissioner Gilroy were also present. After some of the usual business was attended to Mayor Grant presented a resolution wherein it was recited that the Legislature had authorized the board to divide the work of constructing and operating subways between the Consolidated Telegraph and Electrical Subway Company and the Empire City Subway Company (Limited) in such manner that the last-named corporation should take charge

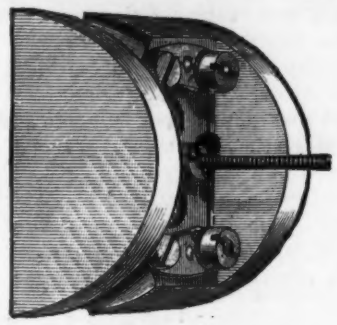


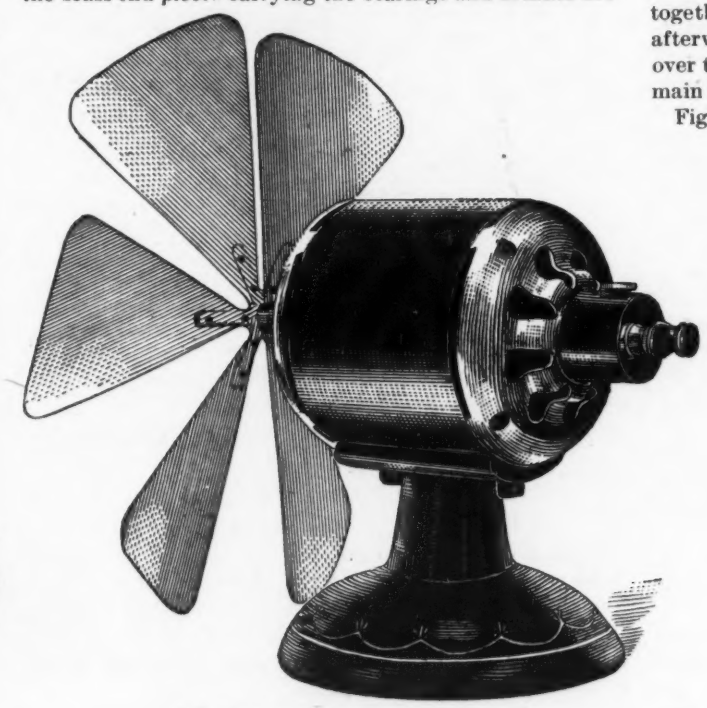
Fig. 2.—The Bathurst Cross-Over Block.

of the low-tension conductors and the old company of all others. This resolution was passed and the new company will at once enter upon its career.

The Wagner Alternating-Current Fan Motor.

Owing to the great number of electric lighting stations now using the alternating current, a great demand has arisen for alternating current motors of small power for driving small fans, sewing-machines, dental lathes, etc.

A novel little motor for this purpose has recently been brought out by the Wagner Electric Manufacturing Company, of St. Louis, Mo. As will be seen from the cut, this motor is exceedingly compact and substantial in its construction. The field is of the form known as iron-clad, and the brass end pieces carrying the bearings and brushes are

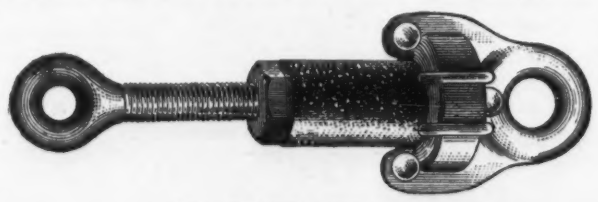


THE WAGNER FAN MOTOR.

designed to protect the armature, commutator and brushes as much as possible, but are readily removed when necessary. The brushes, which are of carbon and self-feeding, need no attention or adjustment, requiring to be replaced but once in two months if used continuously. To renew the brushes it is simply necessary to remove the screw caps serving as binding screws, when the brushes and springs readily drop out. The bearings are self-oiling, and require no more attention than the brushes.

The motor shown in the cut is rated at $\frac{1}{10}$ h. p., and runs a six-bladed 10-inch fan with a pitch of 30 to 35 degrees, 2,000 revolutions per minute, with an expenditure of 100 watts of electrical energy.

These motors can be furnished of $\frac{1}{10}$, $\frac{1}{8}$ and $\frac{1}{4}$ h. p. for pressures from 50 to 110 volts for either alternating or direct currents, furnished with fan, or properly mounted for sewing-machine or dental work. Patterns are now being made for a 1 h. p. motor, which will run at constant speed with any load up to its rated capacity.



Span Wire Insulator.

Railway Span Wire Insulator.

The accompanying illustration shows a new molded mica insulator for span wires manufactured by the Gould & Watson company, of Boston, who have just equipped the Brooklyn City Electric Railway with this style of insulator. It will be seen that this insulator possesses the advantages of a span insulator and turn buckle combined.

In setting up a span the wire is cut off to length and attached to the eye bolts, of which one is unscrewed from its case. One end of the span is hung up with the insulator on the other pole. The free end of the span wire, which is attached to the eye bolt, is strained up with a tackle until it will enter the insulator, which can then be turned up with a wrench sufficiently to strain the span wire. The strength of these insulators is said to be sufficient to break a No. 2 B. W. G. span wire without injury to the material, and it is claimed that spans can be wired with this insulator in one-half the time usually taken.

Bathurst's Cross-Over Block.

Improvements in one department generally call forth improvements in a rival department. We have recently illustrated various improvements in conduit systems for electric wires, and now illustrate an improvement as applied to the methods of installation where wood molding is used to encase and protect the wires of an electric light system.

Mr. Fred. Bathurst, who has had considerable experience in interior construction and installation work, has recently patented in this country an improved arrangement for the crossing of electric wires, a point which, although of great importance in installation, has hitherto been generally neglected, for as often as not "short circuits" and poor insulator resistance can be traced to inferior work at the joints or where a branch crosses the main. Molding work still holds its own for interiors of buildings, particularly where the building is already occupied, and light and power wires have to be put in with the least trouble and annoyance to the occupants, for molding can be quickly and neatly put up and made to accord with existing decorations or wood work.

These blocks not only add neatness and reliability, but save time in installation and the making of joints. By their use both the mains and branches can be put in together, where required, and all joints made together afterwards, thus effecting a considerable saving in time over the ordinary method of lapping one branch on to the main before going into the next.

Fig. 1 shows the block in use with molding. The mains

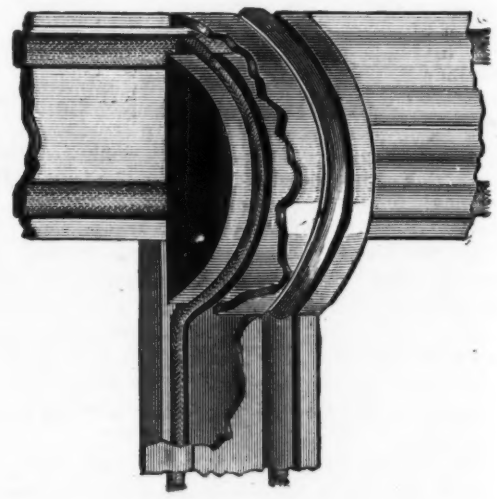


FIG. 1.—THE BATHURST CROSS-OVER BLOCK.

run horizontally, and the branch leads vertically, one of the branch leads crossing over in the groove in the block.

Fig. 2 shows the arrangement of a safety fuse in the block where fuses are to be put on the branch leads. The whole of the brass work carrying current is protected by a neat cover.

Engineering Department of the University of Pennsylvania.

The building for the mechanical engineering department of the University of Pennsylvania has at present a length of 80 feet and is 40 feet wide, and provision has been made for extensions in the future. In the dynamo-room will be located two 100 h. p. compound engines and two engines of the high-speed type, similar to the Porter-Allen, straight line, or Armington & Sims. The Corliss engines now in the department will be removed to this floor, leaving the Porter-Allen engine where it now is, for the purpose of furnishing power to the mechanical workshops of the department, which will remain for the present in the basement of the scientific building. These shops are to be considerably enlarged and improved, so that instruction may be furnished in carpentry, wood turning, chipping, filing, blacksmithing, pattern-making and molding to 50 students at the same time, if this should be desired.

The electric lighting will be partly on the alternating and partly on the direct-current system. Two 500-light 1,000 volts alternating and four 500-light direct-current dynamos are to be employed. As with the boilers and engines, it is proposed to use several types of American machines. The two alternating dynamos will be connected to a separate switchboard, and so arranged as to run either singly or in parallel, or one may be run as a motor. The direct-current machines will be compounded, but so arranged that by throwing a switch they become shunt machines. These will also be so connected to their switchboard as to run separately or in multiple. One alternating and

one direct machine will be connected by belt to each of the compound engines; the remaining dynamos will be driven each by its separate engine. By this arrangement either dynamo or either engine may at any time of the day be used for experiment or instruction, as is the case with the boilers.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

The Providence Telephone Company held its annual meeting on Wednesday of last week. The annual report showed gross earnings $212,929, increase $15,402.59. The old board of directors was re-elected.

The Massachusetts Pulsion Telephone Company made this statement of assets and liabilities March 31, 1891, in connection with the listing of its shares at the Stock Exchange in Boston:

ASSETS.

Cash	$276
Treasury stock, 10,800 shares, at par	54,000
Patents paid for in cash and by stock at par	131.502
New construction	19,192
Telephones in stock	360
Accounts in stock	283
Total	$205,613

LIABILITIES.

Capital stock	$200,000
Materials sold	43
Lines sold	639
Rentals (profit and loss)	4,930
Total	$205,612

The Edison General Electric Company has been given permission by the governing committee of the New York Stock Exchange to list $500,000 additional stock.

The Mexican Telephone Company's directors have organized by the election of the following officers: Robert Colgate, of New York, president; Dr. W. French Smith, of Boston, treasurer, and James Cooney, Jr., of Boston, secretary. Mr. W. A. Paine, of Messrs. Paine, Webber & Co., was chosen a director, vice W. H. Harrington, deceased. Mr. Harrington was secretary and attorney for the company, and performed service of great value in disentangling the company's affairs in Mexico. The annual report was approved and the treasurer was directed to print and mail it to shareholders, and it is said that this will be done in about two weeks.

The Edison Electric Illuminating Company, of Boston, organized under the laws of Massachusetts, has been admitted to the list of the Boston Stock Exchange. In addition to the facts given in this column last week regarding this stock it may be stated that the stock is non-assessable, its par value being $100 paid in cash on each share. The authorized capital is $2,000,000; amount of capital issued, $1,263,500; convertible debenture bonds of March 1, 1888, ten years, payable unless converted March 1, 1898, $150,000; convertible debenture bonds of May 1, 1891, ten years, payable unless converted May 1, 1901, $586,500. Of this latter issue $85,000 in bonds will remain in the treasury.

The following earnings are reported for the quarter ended March 31:

	1891.	1890.		
Gross	$1,537,042	$1,361,573	I.	$175,469
Expenses	864,465	769,153	I.	95,312
Net	$672,577	$592,420	I.	$80,157
Charges	582,915	552,749	I.	30,166
Balance	$89,662	$39,671	I.	$49,991

Detroit Electrical Works.—Messrs. Irving A. Evans & Co. of Boston, have issued another letter in relation to the merits of the Detroit Electrical Works, on which they are very enthusiastic because of its excellent management and its low capitalization compared with its earning capacity. They say: "In a short time, by the erection of additional factories, the producing capacity of the works will be more than doubled; and the street railway motor department will be able to turn out five motors a day, a record equal to that of any other electrical company in this country. The works are now running day and night, and yet are unable to keep even with their orders."

Capital Required in Electrical Industries.—Investors are beginning to realize that the magnitude of the electrical industries requires a correspondingly large capital. On this subject the Boston *News Bureau* says: "Some idea of the capital required in the electric manufacturing business may be obtained from the fact, admitted by both the Thomson-Houston and the Westinghouse people, that it takes about eight months to turn raw materials into cash through the manufacture of electric apparatus."

The Mexican Central Telephone Company adjourned its annual meeting last week to May 27. The treasurer's report showed remittances from Mexico of $2,800 during the year, to which should be added $331.05 cash on hand in May, 1889, making

Total receipts		$3,131.05
Interest	$1,200.00	
Dividends	886.72	
Sundries	451.84	
		2,538.56
Balance May, 1890		$592.49

Thomson-Houston.—The Boston *Beacon* says that Thomson-Houston shareholders are likely to receive subscription rights within a few weeks, and that the business is conducted pretty much as formerly and with the usual variety of cash transactions.

Westinghouse Stock is quoted at practically the same figure as it was one week ago. The main features of the reorganization plan, as set forth in a circular sent out to stockholders on the 9th inst., were outlined in this column last week. A majority of the stockholders have given their assent to the reorganization plan and are rapidly surrendering their stock. A Pittsburgh creditor of the company, speaking of the reorganization plan, says: "It will put the company firmly on its feet. With the new Eastern men prominent in the management of its affairs, Westinghouse Electric will be run on sound business principles and give confidence to the stockholders and the public. Economy in operation, the great success sure to be secured in the electric railway business, and such backing in capital and credit as will enable the corporation to give long credits, will insure larger net earnings than ever before. The reorganization will not increase the capital stock, as many here feared it would do. It is probable that over ninety per cent. of the stockholders will give their assent to the plan, and I am informed that every one of the note creditors have consented to the arrangement." In Boston during the week 70 was bid for Westinghouse scrip by a house identified with the property. It was some 40 bid not long ago. This is dividend scrip, issued on the stock of the old company, and some 200,000 of it is outstanding

At the adjourned meeting held in Pittsburg May 18 no business of importance was transacted. More time was needed to enable the stockholders to conveniently make the necessary transfers of stock, and after a brief formal meeting an adjournment was taken until June 1, by which time the work of reorganization will probably be complete.

The Closing Quotations of electric stocks, from F. Z. Maguire & Co., electrical securities, 18 Wall street, New York, on Saturday, May 16, 1891, in New York, Boston and Washington were:

Name of Stock.	Par.	Capitalization.	Bid.	Ask'd.
NEW YORK.				
Western Union Telegraph Co	100	86,200,000	80¼	80½
American Telegraph & Cable	100	14,000,000	80½	....
Central and South American	100	5,600,000	145	160
Mexican	100	2,000,000	205	220
Commercial Cable Co	100	7,716,000	105	106½
Postal Telegraph Cable	100	5,000,000	39	41
Edison General Electric Co	100	9,503,500	101	102
" " Deferred	100	2,496,500	....	....
Consolidated Electric Light	100	1,929,400	....	....
Edison Electric Illuminating Co.	100	2,567,800	76	78
United States Electric Light	100	1,500,000	30	31
North American Phonograph	100	6,200,000	....	....
BOSTON.				
Thomson-Houston Electric Co	25	6,000,000	44½	45
" " preferred	25	4,000,000	25½	25⅞
" " Series C	10	400,000	....	....
" " Series D	10	120,000	7	7¼
" International Co	100	1,000,000	....	....
Thomson Welding Co	100	1 000,000	....	....
" European Welding Co	100	1,000,000	55	60
Ft. Wayne Electric Co	25	4,000,000	12	12¾
Detroit Electrical Works	..	.....	12¼	12¾
Westinghouse Electric Co	..	.....	15	15¼
Telephone:				
American Bell	100	12.500,000	203	204
Erie	100	4,800,000	48	49
New England	100	10,504,600	....	53
Mexican	10	1.280,000	90c.	1.00
Tropical American	10	400.000	50c.	....
Edison Phonograph Doll	10	1,000,000	50c.	1.00
WASHINGTON.				
Pennsylvania Telephone	50	750,000	25	....
Chesapeake & Potomac	100	2,650,000	60½	64
American Graphophone	10	600,000	5⅞	7
United States Electric Light (Washington)	100	300,000	161½	169
Eckington and Soldiers' Home Electric Ry	50	352,000	48	50
Georgetown and Tennallytown	50	200,000	59½	61

Chicago Quotations.—Col. S. G. Lynch, broker, 153 Monroe street, Chicago, furnishes quotations on telephone and electric light stocks as follows:

Chicago	$230@$240	Cumberland	$60@ $62
Central Union	56@ 57	Wisconsin	118@ 120
Michigan	86@ 88	Bell of Missouri	160@ 165
Great Southern	30@ 32	Iowa Union	20@ 22
Colorado	34@ 36	Missouri and Kansas	54@ 56
Rocky Mountain Bell.	40@ 43		

ELECTRIC LIGHT STOCKS.

Chicago Arc Light and Power	$104@$105	Chicago Edison Co	$145@$150

NEW INCORPORATIONS.

The Colorado Electric Light Company, of Colorado City, Tex., has been incorporated with a capital stock of $10,000.

The Leominster (Mass.) Street Railway Company has been incorporated with a capital of $50,000, by G. F. Morse, G. R. Wallace, M. D. Howe and others.

The Maxstadt Electric Company, of Chicago, has been incorporated with a capital of $100,000, by F. W. Maxstadt, C. S. Cleaves and William L. Marston.

The Consumers' Electric Lighting and Power Company has been incorporated at St. Louis, Mo. The capital stock is $750,000. Andrew J. Cooper, of Chicago, is one of the stockholders.

The Independent Lighting and Supply Company has been incorporated in Chicago, Ill., with a capital of $50,000. The incorporators are: George S. Markham, Benjamin A. May and Ernest T. Loomis.

The Maine Electrical Improvement Company, of Brunswick, Me., has been incorporated with a capital stock of $25,000. Mr. Alexander Henderson is president of the company; James S. Doolittle, secretary and treasurer, and Mr. Thomas J. Fay is the general manager. Mr. Fay is well known among New York people through his connection with the Hunt Engineering Company, the Complete Electrical Construction Company and other engineering firms. Mr. Henderson has also been connected with the Hunt Engineering Company, and more recently with the Manhattan Electric Light Company. Mr. Doolittle is a well known financier and banker of Brunswick, Me. The New York office will be located in the new Electrical Exchange Building, which is now being fitted up. The home office of the company is at Brunswick, Me. The company is prepared to undertake the improvement and development of patents and specialties, to superintend the erection and equipment of electric light and power plants, to furnish detailed drawings, specifications and electrical tests, and to make reports on all classes of engineering work.

AFFAIRS OF THE COMPANIES.

The Walter Hay Manufacturing Company, of St. Louis, Mo., has been succeeded by the Hay-Horn Manufacturing Company, with increased capital and larger quarters. The partners are Walter Hay and Geo. E. Horn.

The Faraday Heat, Power and Light Company, of Morton, Pa., held its annual meeting last week, and elected the following directors: Richard Young, Edward Sellers, Thomas J. Hunt, Robert Patterson, J. F. Beatty, Dr. A. R. Morton and Garrett E. Smedley.

The Atlantic Postal Telegraph Company held its annual meeting last week in Camden, N. J. The following officers were elected: C. C. Adams, George G. Glenn and James Donally. C. C. Adams was elected president, and George W. Glenn secretary and treasurer.

The Chartiers Valley (Pa.) Light Company has obtained control of the Chartiers Electric Light Company. These two companies have been supplying light to the borough of Chartiers and the new combination will extend the system to the neighboring villages. Mr. S. A. Duncan, of Pittsburgh, Pa., is interested in the controlling company.

The Union Switch and Signal Company has of late met with some further changes. Mr. A. T. Rowand has resigned from the vice-presidency of the concern. Mr. Rowand also resigns as a director of the company, and Mr. G. P. Shane, who became a member of the board along with Mr. Rowand, also hands in his resignation. Mr. Rowand retains his connection with the East End Electric Light Company. It is his intention to make a somewhat lengthy sojourn in California for his health.

The Seattle (Wash.) Consolidated Street Railway Company last week filed a trust deed of all its property to the Central Trust Company, of New York, to secure an issue of $1,000,000 of first mortgage bonds. The Consolidated Street Railway Company is the new corporation which recently bought the property and franchises of the Seattle Electric Railway and Power Company, and is composed of the stockholders of the old company with the addition of several Eastern capitalists. The capital stock is $1,200,000, part of which was issued to the stockholders of the old company in payment for the property. Of the new issue of bonds part is issued to old stockholders, together with the new stock, in payment for the property; part will be used in retiring the $400,000 of bonds outstanding against the old company, and the remainder will be marketed, the proceeds to be expended in increasing the equipment and making extensions of the lines. L. H. Griffith, president of the new company, will return in a few days from San Francisco, and the trustees of the consolidated company will then determine what new lines shall be built and new equipment purchased.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
167-177 TIMES BUILDING, NEW YORK, May 18, 1891.

Mr. D. B. Dean, of the Electric Merchandise Company, of Chicago, was in the city during last week.

Mr. J. Frank Morrison, of Baltimore, well-known in electrical circles, made a flying trip to the metropolis last week.

Mr. W. A. Stadleman, of Philadelphia, the well-known electrical engineer, was in New York on a business trip last week.

Mr. C. C. Allen, manager of the Boston Electric Company, was a caller at our office last week and reports business as very lively.

Mr. D. A. Andrews, Jr., of the Pettingell-Andrews Company, Boston, was in New York last week. Mr. Andrews says "K. W." cut-outs still lead the procession.

Mr. A. H. Suren, formerly representing the Edison Electric Light Company at Fort Worth, Tex., is now connected with M. D. Porter, at 173 Greenwich street, New York.

The Walker Meter Company has removed the old offices at 50 Broadway to offices on the same floor formerly occupied by the National Electric Manufacturing Company.

The Standard Paint Company, of New York, is sending a neat box containing a sample of its P & B insulating tape to every central station in this country and South America.

Mr. G. W. Davenport, general manager of the Thomson-Houston International Company, arrived home from Europe on the "Trave," of the North German Lloyd line, last week.

Mr. Frank C. Perkins, the author of the "Cornell Handbook," noticed in THE ELECTRICAL WORLD of last week, has written us to say that the book will be presented to members of the American Institute of Electrical Engineers who are present at the annual meeting to be held in this city this week.

Mr. F. H. Sparling, formerly of the Northwest Electrical Supply and Construction Company, of Seattle, Wash., is now connected with the enterprising supply dealers, W. H. Gordon & Co., of 115 Broadway, this city. Mr. Sparling has a host of friends and will be a valuable addition to this pushing company.

The McCreary Electrical Specialty Company is busy getting settled in its new offices at 136 Liberty Street, rooms 205 and 207 in the new Electrical Exchange Building. A special "dark" room is being fitted up so as to show all the company's specialties as they really are in connection with the electric light.

Tunnel Lighting.—Governor Hill has signed the bill empowering the Railroad Commissioners to compel railroad companies to light and ventilate tunnels properly. This legislation is a sequel to the tunnel accident in Fourth avenue not long ago. Despite the indictment of the directors of the New Haven road in connection therewith, general interest in improving the safety of this and other tunnels has seemingly died out. The latest reports were that the use of electricity for illuminating purposes was impracticable.

New York Meeting of A. I. E. E.—The Electric Club will tender the privileges of its house to the members of the American Institute of Electrical Engineers, which holds its annual meeting in this city this month. At the first meeting of the new Board of Managers of the Electric Club the following committees for the ensuing year were appointed: House Committee—P. H. Alexander, chairman; Charles D. Shain and Stephen L. Coles. Entertainment Committee—T. C. Martin, C. E. Stump and Charles W. Price. Finance Committee—President Insull, George M. Phelps and P. H. Alexander. Electrical Committee—Charles D. Shain, E. A. Leslie and Herbert Laws Webb. Library Committee—Edward Weston, Joseph Wetzler and Stephen L. Coles.

The Jersey City Electric Light Company, under the superintendency of Mr. W. W. Titzell, has prospered and had a remarkable growth. The company is now lighting 330 arcs and 5,200 incandescents, and also furnishes power to drive the 80 h. p. Thomson-Houston dynamo for the Jersey City electric railway. This road is now being extended from the ferry to Greenville, about ten miles, and three more 80 h. p. Thomson-Houston generators are to be added. The Electric Light company is also arranging to add more generators, to furnish power for a motor circuit for running fans and small power. Three 1,000-light Fort Wayne Slattery induction machines at this station attract especial attention, for the reason that they have been running constantly for one and one-half years, one of them running as high as 1,600 lights and working 24 hours a day, the others running 12 hours a day, with almost always an overload. Not an armature has been burned out, notwithstanding the fact that during severe storms numerous converters, lightning arresters, and fuses have been destroyed. L. H. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
Room 28, Hathaway Building, 620 Atlantic Ave.,
BOSTON, May 16, 1891.

Mr. Fred H. Angel has resigned his position with E. M. Carhart & Co., of Providence, R. I., to engage in other business.

Thompson, Crawford & Co., of New York, have secured the contract for the new electric railway from Hartford to Glastonbury, Conn.

Removal.—The American Bell Telephone Company has removed its general offices, which have so long been located at 95

Milk street, Boston, to the new Telephone Building at 125 Milk street.

The Marlboro Electric Street Railway has been compelled to close down operations altogether on account of the building of a sewer, which, it is expected, will take about six weeks.

The Germania Electric Company, of Cambridgeport, Mass., has removed its offices to Room 505, Exchange Building, 53 State street, Boston, to which address all correspondence should now be sent.

The Malden Electric Company had an accident in its plant last week. The main steam pipe exploded, doing about $500 damage, which was repaired, and the lights were again working Wednesday night as usual.

Mr. George W. Blodgett, of the Boston & Albany Railway, gave a lecture before the Society of Arts at the Massachusetts Institute of Technology, Thursday night, on the subject of "New Electric Signaling Apparatus for Railways."

Little Compton, R. I., is to be connected with the outside world by an electric railway to run to the Tiverton Station of the Old Colony Railroad. The Westinghouse Electric and Manufacturing Company will build the road, and it is to be running in three months.

Southbridge, Mass.—Mr. C. D. Paige has resigned his position as treasurer of the Gas and Electric Company, and is to be succeeded by Mr. C. W. Johnson. Mr. A. McLean has been appointed general manager and superintendent of the plant, and will have charge of the practical part of the business.

The Thomson Scientific Club held its second anniversary banquet at the new club house at West Lynn, Mass., Wednesday. Covers were laid for 75. The speech of the evening was by Prof. Thomson, on the subject "The Application of Electricity to Railways." A very pleasant time was enjoyed by all.

Messrs. Bradbury & Stone, of Lowell, Mass., are fitting up a very commodious shop, corner of Howard and Middlesex streets, for the manufacture of their improved storage battery, which is undoubtedly one of the best on the market. The added facilities will enable them to fill orders promptly in future.

Mr. Elliott O. Johnson has severed his connection with the Standard Electric Supply Company and accepted a position as general sales agent for the Redding Electric Company. Mr. Johnson is well and favorably known to the trade and public, and will undoubtedly prove a good acquisition to the Redding Company, which is now located at 41 Federal street, Boston. The office is being nicely fitted up for the company's use, and will be in shape in about a week.

The Waters Electric Company, of Brockton, Mass., has recently increased its capital to $250,000. It proposes to push the Waters electric window switch and Waters corridor switch, both of which are considered to be valuable inventions. The present officials of the company are such well-known business men as W. F. Jones, president; R. E. Tilton, vice-president; E. B. Jones, secretary, and A. W. Otis, treasurer. With these gentlemen at its head the company ought to be very successful.

New England Electric Exchange Meeting was held last week in the rooms of the Boston Electric Club. Mr. H. B. Cram was elected chairman *pro tem.*, and Mr. Timothy W. Sprague, secretary and treasurer, read the records of last meeting. One of the items of business to be transacted was the election of officers for the coming year, but owing to the small attendance Mr. W. S. Hill moved that the election should be deferred until the next meeting. The report of the committee appointed some time ago to confer with the representatives of the New England Insurance Exchange and Boston Board of Fire Underwriters was submitted, debated, placed upon file and the committee discharged. Mr. C. M. Goddard, electrical inspector for the New England Insurance Exchange, offered some judicious suggestions about the inspection of electric wires, which were listened to with interest by those present. Mr. Alex. P. Wright, president of the Electric Exchange, being absent in England, but expected home shortly, it was resolved to adjourn further business until his return, when an important meeting will be held. C. A. B.

WESTERN NOTES.

Branch Office of The Electrical World,
465 The Rookery, Chicago, May 16, 1891.

Mr. Wiley W. Smith, of Kansas City, is a welcome visitor in Chicago this week.

The Charles Munson Belting Company, Chicago, has sold 150 feet of 58-inch belt to Pittsburgh parties.

Mr. J. F. Urquhart, of the Thomson-Houston Carbon Company, called on his friends in Chicago this week.

New York Visitors.—Mr. Thomas A. Edison and Mr. Samuel Insull, of New York, favored Chicago with their presence this week.

Mr. A. Groetzinger, of Chicago, has been elected president of the Charles Munson Belting Company, of which company he has for a long time been vice-president.

Mr. H. M. Underwood, the Western agent of the Interior Conduit and Insulation Company, has secured the contract for electrically conduiting the extensive Fair building, Chicago.

Messrs. Wyckoff, Seamans & Benedict, proprietors of the Remington standard typewriter, have secured larger quarters, with improved facilities, at No. 175 Monroe street, which they will occupy about the 18th inst.

Mr. H. T. Paiste, of Philadelphia, has been in Chicago arranging for the opening of a branch house, where a full line of Paiste specialties will be carried, thus insuring prompt deliveries to Western buyers. This branch will be under the direct management of Mr. Paiste, with Messrs. Kohler Brothers and Grier in charge.

Mr. J. T. Harris, the Chicago manager of the Heine Safety Boiler Company, has secured contracts for the installation of a 150 h. p. Heine boiler in the station of the Ann Arbor (Mich.) Thomson-Houston Electric Light Company, and for two 150 h. p. Heine boilers in the station of the Cedar Rapids (Ia.) Electric Light and Power Company.

The New York Insulated Wire Company is opening a handsome set of offices at 78, 80 and 82 Franklin street, Chicago, and will have an opportunity to display Grimshaw wires and its specialties in the three handsome show windows at the company's disposal. Mr. George C. Meeker will assume the management shortly, the work of opening the establishment being now in the hands of Mr. J. W. Godfrey, the general manager of the company.

The Chicago Electric Manufacturing Company, 73 Jackson street, has received such an amount of business from the various supply houses desiring the manufacture of high grade specialties, that the company has been compelled to secure larger quarters, and has moved to the second floor of the same building, and added the necessary new machinery to enable it to keep up with orders received. At present the company is manufacturing special resistance devices, stage regulators, special switches having large carrying capacity, and ammeters and voltmeters.

The Electrical Engineering Company, 603 Monon Building, Chicago, is meeting with excellent success in introducing the new Standard dynamo for isolated lighting, and has already contracted to install several machines, one of the latest being in the Dunshee apartment house. This company is placing several of the Perret fan motors in offices, and is carrying both large and small Perret motors in stock. The company is not doing a supply business, but has secured the Western agency of the well known Clark wire, and is pushing its sale, as well as using it in all important installations where high insulation is desired. Mr. R. H. Pierce, long connected with the Edison Company, is well known throughout the West for his high standard of "only the best," and, with the assistance of Messrs. Richardson, Izard and Seymour, is certain to win many friends for the new company wherever high-class work is desired.

Edison Business in Chicago.—The building owned by Gen. Henry Strong, of Washington, Nos. 173 and 175 Adams street, has been leased to the Western Edison Electric Company for a term of 10 years. The building is a modern brick structure, six stories high, having a frontage on Adams street of 50 feet and a depth of 175 feet. The price paid for the term of 10 years is $150,000, or $15,000 a year. The lease dates from Jan. 1, 1892, but the Edison Company will take possession July 1, when the work of remodeling the structure to conform to the wishes of the lessees will begin. About $25,000 will be expended in improvements. Although the business of the company in Chicago and in the West demands an increase in space, the present change would not be made were it not that Mr. Edison desires to establish in Chicago a branch of his business which heretofore has been transacted in New York. The decorative bronze work of the company, started a few years ago in a small way, has grown to such proportions that the New York plant cannot take care of it all. It is proposed to devote a large portion of the Adams street building to this enterprise. All the goods used in construction work in the West will be kept here, as well as 500,000 incandescent lights. The lower floor will be used as a show room to display the products of the Edison companies.

F. de L.

Cleveland, O., May 16, 1891.

Colonel J. H. Shay, of the Charles Munson Belting Company, of Chicago, was a welcome visitor in Cleveland this week.

Mr. Morris W. Mead, Chief of the Bureau of Electricity of the city of Pittsburgh, passed last Sunday at the Hollenden House.

Mr. Robert Rennert and Mrs. Rennert, of Baltimore, were among the attendants at the hotel men's convention in Cleveland this week.

The Globe Carbon Company, of Cleveland, has broken ground for its new works at Ravenna, O., and these will be completed about Sept. 1. The company is to increase the capacity of the works three fold.

Mr. S. S. Leonard, of the Hill Clutch Works, Cleveland, Ohio, has just closed a large contract with the Buffalo Electric Light Company for the complete equipment of the extension to the plant, as well as the contract for the increase in the power plant of the East Cleveland Street Railway Company, including all the shafting, clutch couplings and pulleys. Two new 600 h. p. Corliss engines will be added.

The Hill Clutch Works, of Cleveland, has secured the contract for the shafting, clutch couplings, pulleys, belt tighteners, belts, etc., for the St. Louis and Suburban Railway power station, and has also secured orders for an addition to the power plant of the Missouri Railway of a 1,000 h. p. Corliss engine, clutch pulleys 96 inches × 36 inches in size, to which will be belted 400 h. p. generators, both pulleys and generators being of unusual size. The company also has an order from the West End Railway Company, of Boston, for 15 clutch pulleys with 84-inch face, having a transmitting capacity of 4,000 h. p., and four clutch pulleys having a 72-inch face and transmitting 2,500 h. p. at 200 revolutions.

ENGLISH NOTES.

London, May 6, 1891.

Electric Cranes.—The authorities in connection with the great mail steamer port of Southampton have decided to adopt electric cranes for use in their business, the current being obtained from the mains of a local supply company. The matter, as is usual with us, was under discussion for a long time, and electricity was only adopted because of the advantages it offered from the point of view of getting the cranes rapidly to work, the cost of steam power being considerably less than that of electricity.

Science vs. Art.—The science laboratories at South Kensington, but recently threatened by an underground electric railway, are now in danger of having their future development rendered difficult, if not impossible, by the erection, in close proximity to them, of an art gallery on land bought last year at a cost of £100,000 for the special purpose of science. Against this proposed gallery of British art considerable protest has already been made by scientific men, and an influential memorial is now being extensively signed urging upon the Prime Minister, himself a man of science, to prevent the future utility of Kensington being hampered in this way.

Alternating Constant Current Distribution.—A French electrician, M. Boucherot, has for some time past been contributing brief but interesting articles on the employment of condensers and induction coils in connection with alternate currents. In one of these he points out that by employing a condenser and a choking coil in series, shunted by an arc lamp, the whole being placed across constant potential mains, a constant current might be obtained in the lamp, since the voltage at the terminals of the condenser and coil falls and rises with the resistance of the shunt. Many minds are now engaged in this country in evolving a condenser which shall be fairly cheap and stand high alternating potentials. If such a condenser is forthcoming, and an efficient high frequency alternator is also obtainable, the use of condensers would soon become commercially practicable.

The Candle Power of Arc Lamps.—The admittedly unsatisfactory method of classifying arc lamps according to their supposed candle power instead of to the amount of current they take is likely to result at Bath, where arcs are largely used in the lighting of the streets, in a grave dispute if not in litigation. In the contract, lamps of 1,200 c. p. were specified for, and the town council being of opinion that they were not getting that amount of light called in Prof. George Forbes, who told them that with the opal globes employed the mean spherical candle power was not more than 300 or 400. This resulted in a lengthy correspondence between Prof. Forbes and the agents of the Thomson-Houston company in this country (the Laing, Wharton and Down Construction Syndicate), who supplied the plant. The latter asserted that the so-called 1,200 c. p. lamp actually gave without globes at an angle of from 40 to 60 degrees from the horizontal more than the specified amount of light, but they admitted it was possible with the globes employed, and taking the average illumination, that the complaints of the authorities might have some ground. The matter is still under consideration, and should it lead to electric lighting contractors specifying the candle power of the lamps supplied in a more satisfactory manner, the dispute will not have been without its uses.

The Comparative Cost of Arc and High Candle Power Incandescent Lamps.—The comparative cost of arc and high candle power incandescent lamps has for some time past been a moot point with electrical engineers in this country. The type of high candle power incandescent lamp best known in this country is called the "Sunbeam," and some interesting particulars have recently been published in connection with the cost of running 500 c. p. "Sunbeam" lamps for dock-lighting purposes, as compared with arc lamps of 2,000 *nominal* c. p. The cost of working a 2,000 c. p. 10-ampère arc from sunset to sunrise throughout the year, or for about 4,200 hours per annum, was found to be close upon £16, including carbons, coal and attendance. The cost of working a 500 c. p. "Sunbeam" lamp, including renewals (three lamps per annum) and coal, was close upon £12. It would thus appear that there is a decided gain in economy by using high candle power incandescent lamps, for the 500 c. p. "Sunbeam" does not give in practice so very much less light than a 2,000 nominal c. p. arc. Of course the chief item is coal, and where coal is dear the positions of the two lamps on the economic scale might probably be changed. In the present instance good coal was obtainable at 14s. per ton. It must also be remarked that the efficiency of the "Sunbeam" was somewhat overrated, since it was taken as averaging three watts per candle, while the efficiency of the arc lamp was somewhat underrated.

Answers to Correspondents.

Questions to be answered in this column must be of general electrical interest, and must be accompanied by real name and address as a guarantee of good faith. No notice will be taken of questions regarding apparatus unless enough details are given to permit a definite answer, and no dynamo or motor designing will be done.

Centre of Distribution.—In your correspondents' column will you please explain how to find the centre of distribution. Suppose we have five lamps located 10 feet, 15 feet, 25 feet, 40 feet and 60 feet from the converter, how many feet from the converter would be the centre of distribution and what would be the size of wire required? J. H. W.

The centre of distribution is the "centre of gravity" of the figure formed by the lamps as points of limit. In the example given, if the lamps are in a straight line, the centre of distribution is as many feet from the converter as would be the point of balance or centre of gravity from the near end in a beam 60 feet long and loaded with equal weights 10, 15, 25, 40 and 60 feet from one end.

Raising Circuit Potential by Transformers.—1. Please explain why I cannot raise the voltage in a circuit with transformers by connecting across the lines the terminals of two primary coils in multiple and the terminals of the two secondary coils in series?—the ratio of conversion of above transformers being 20 to 1. C. L. S.

It is not possible to obtain good results when both the primary and the secondary terminal are connected to the line in multiple. The Stillwell regulator, used in the Westinghouse system, comprises most likely the principle to which you refer. In this device a coil of many turns is connected *in multiple* with the dynamo circuit, and is in inductive relation to a "secondary" coil of heavy wire and fewer turns, the convolutions of which are connected (in greater or less number) *in series* with the dynamo circuit. This causes either a rise or fall of potential according to the relative arrangement of the coils. The company will probably send a diagram upon application.

News of the Week.

THE TELEGRAPH.

The New Halifax Cable is to extend from Halifax to Jamaica and all the British West Indian possessions and to British Guiana, and it is stated that work will be commenced during the summer.

New Telegraph Lines.—A company is erecting its poles throughout Monmouth county, and offices will be established in all the principal towns. The line will extend as far south as Asbury Park, and, if business warrants, it will be extended still further. One of the company's principal offices will be in Red Bank.

A New Book on American Telegraphy.—The announcement is made by the publishers, J. H. Bunnell & Co., this city, that a new book on the above subject is now in press and will shortly be issued. The book will comprise about 600 pages, including over 400 diagrams, and will cover very completely the systems of telegraphy now in use in this country, describing very fully their method of operation.

THE TELEPHONE.

San Francisco, Cal.—The work of laying the underground telephone cable has begun. When the underground system is completed there will be 6,000 miles of wire disposed of.

Albany, N. Y.—The Hudson River Telephone Company has awarded the contract to the National Conduit Company, of New York, to lay the conduit line. The work will begin at once.

Bartow, Fla.—The South Florida Telephone Company is carrying on a large business, having strung wires all over the county. The company now has a contract for erecting a line at Leesburg, Fla.

Vicksburg, Miss., has one of the most prosperous telephone companies in the country. The company has now 250 subscribers, and the system is to be extended to meet the increasing demand for telephones.

The New England Telephone and Telegraph Company is constructing a metallic circuit long-distance line through Exeter and Portsmouth, N. H., to Newburyport, Mass., where direct communication will be established with Boston.

Santa Fe, N. M.—Mr. C. C. Everhart has arranged with the Colorado Telephone Company to establish a telephone exchange in Santa Fé, provided sufficient interest is shown by the business community to subscribe for 35 telephones. He has only started in on the enterprise, but thus far has 22 subscribers on his list.

THE ELECTRIC RAILWAY.

Massillon and Canton, O., may be connected by an electric street railway before snow flies. That a street railway will be at once constructed in Massillon is a certainty, and one branch will probably be extended to the Canton limits.

The American Street Railway Association, through its secretary, Mr. William J. Richardson, of Brooklyn, has sent us an India proof of a steel-plate engraving of Mr. Thomas Lowry, president of the association for the year 1889-90, which is to appear in the report of the last annual meeting.

The Field Engineering Company, whose offices are in the Central Building, New York City, has issued a little eight-page pamphlet containing data on electric railway work, including the cost of steam plant, generators, station and car equipment. Considerable information is given in detail regarding the cost of equipment of electrical street railways of different systems. The folder also contains two illustrations, one of the plant of the Newark Passenger Railway Company, of Newark, N. J., and the other of the Buffalo Railway plant, both of which were designed and constructed by the Field Engineering Company, the former being a 4,000 h. p. plant, and the latter for 5,500 capacity.

American Railways for Foreign Countries.—The Electric Merchandise Company, of Chicago, has received during the past few months a number of orders from tramway companies in foreign countries for American material, and has also received numerous inquiries regarding the practical working of electric street railways in this country. The managers of the company have thus been led to look into the matter, and, after correspondence with parties interested, have formed the opinion that foreign roads are ready to adopt the electric railway system as used in this country at once if its advantages can be freely explained to them. This company has sent Mr. Frank X. Cicott as its representative to foreign countries, where he will probably spend two months in working up an interest in such matters as relate to the installation of American electric railway systems in those countries. Mr. Cicott sailed on the Cunard steamship "Servia" from New York on the 9th inst.

THE ELECTRIC LIGHT.

La Grange, Tex., will advertise for bids for a system of electric lights.

Walkerville, Mont., has adopted electric lighting for a number of its streets.

Shenandoah, Ia., will be illuminated by electric light shortly. At an election last week a local company was voted a franchise for ten years.

Allegheny, Pa.—The test of the tower system of electric lighting has not shown the system to be all that is required and the city is to adopt the mast-arm system as used in Pittsburgh.

Mineola, Tex.—A company of capitalists is corresponding relative to the erection of an electric light plant in Mineola, for which, with other public improvements, they propose to expend $75,000.

Mr. H. M. Lyman, superintendent and electrician of the Canton (O.) Electric Light and Power Company, installed 24 new arc lights on his commercial circuits during the month of March, which speaks well for the excellent service rendered.

Philadelphia, Pa.—The Councils' Electrical Committee last week recommended favorably the ordinance granting to the Southern Electric Light Company the right to erect poles and wires in the territory bounded by South street and the Delaware and Schuylkill rivers, and exempting the Thirty-fifth ward from payment of taxes on poles.

The Fort Wayne Electric Company has sold through its New York office a 1,300 alternating plant to the Asbury Park (N. J.) Electric Light and Power Company; a similar plant to the Richmond Light, Heat and Power Company, of Staten Island, and a 650 alternating plant to the Alumbrado Electric Company de Barranquilla, United States of Colombia, S. A.

Des Moines, Ia.—The Water Power Light Company has the engine-houses nearly all wired for electric light, and it will be only a few days till the gas will be displaced, at a saving to the city of over $700 a year. The Board of public Works will contract with the same company for 100 arc lights or more at $6 per month per light. This will be a saving of $5.75 per light per month, and will be also cheaper than gas, which the arc lights will displace on most of the principal streets.

GENERAL APPLICATIONS OF POWER.

Electric Power for Printing.—The Steelton, Pa., *Reporter* is now equipped with an electric power plant for running all its printing and other machinery.

The Jeffrey Manufacturing Company has lately installed electric coal mining plants as follows: Helvetia mines, Helvetia, Pa., four electrical machines; Red Stone Coal and Coke Company, Grindstone, Pa., two electrical machines; Union Colliery Company, Victoria, B. C., four electrical machines. These plants are all running with perfect satisfaction.

Mathews, Widmer & Co., electric supply dealers of New Orleans, La., report the sale of the following "Eddy" motors: To B. M. Elder, 2 h. p. for knitting machinery; D. H. Holmes, two of 10 h. p. each for passenger elevators; Marchal & Ducros, 1 h. p. for coffee mills; David Jackson, 3 h. p. for ventilating fans; Emile Bauman, ½ h. p. for ventilating fans; W. T. Clurerius, 1 h. p. for ventilating fans; M. O. Spring, 5 h. p. for bicycle machinery; Standard Manufacturing Company, 2 h. p. for sewing machines, and to Delvado & Co., 5 h. p. for freight elevator.

LEGAL NOTES.

Western Union Associated Press Rates in Nebraska.—The Lincoln, Neb., *Call* Publishing Company has brought suit against the Western Union Telegraph Company for $1,962 damages for the alleged discrimination of that company against the *Call* Publishing Company in transmitting Associated Press dispatches. The *Call* Company alleges that it is charged $5 per 1,000 words, while another paper gets the same service at $2.50 for each 1,000 words.

Unassembled Bell Receivers Infringe.—The American Bell Telephone Company secured a final decree in the Federal Court in Chicago, Ill., last week against Arthur F. Arnold, who manufactured and sold telephone receivers infringing on the Bell patent. Arnold made the peculiar defence that he sent the receivers out in sections, and if there was any infringement it was on the part of the people who bought the sections of the receiver and put them together and used them.

PERSONALS.

Mr. E. L. Burdick, publisher of the *Roller Mill* of Buffalo, N. Y., was in the city last week attending the millers' convention, and called on many old friends.

Mr. W. A. Fenn, for six years associated with the Bunnell Company, of New York City, has accepted a position as general manager of the American Electric Supply Company, of Buffalo, N. Y.

Mr. J. L. Barclay, the well-known Chicago agent of the Westinghouse Electric and Manufacturing Company, is in Pittsburgh, Pa. Mr. Barclay states that the company has been doing a considerable amount of railway work lately.

Industrial and Trade Notes.

The Ball Engine Company, of Erie, Pa., owing to the enormous increase in its business during the past year, has found it necessary to erect an extension to its works.

Messrs. Taylor & Son, of 39 Dey street, New York, are very busy with orders for their primary battery and depolarizing powder. During the last week a large order was filled for their battery for export.

Messrs. Pass & Seymour, of Syracuse, N. Y., manufacturers of china and porcelain electrical fittings, have been doing a very large business lately, the average number of pieces sold being 200,000 per month.

A Perforated Belt.—The local electric light company of Owensboro, Ky., to which Messrs. Schieren & Co. lately gave the privilege of perforating a belt by their process, commends perforating in the highest terms, saying that the belt is giving excellent satisfaction.

E. A. Wildt & Co., of 83 Murray street, New York City, desiring to extend their already well-established business, have issued a number of attractive circulars calling the attention of the public to the large reductions recently made in the price of annunciators, door openers, bells, letter boxes, etc.

The Mica Asbetite Insulating Company, of Denver, Colo., is placing on the market a complete line of Kimble's electrical appliances especially designed for street railway service and made from a compound of which atomized mica is the foundation. Among the devices are pull-overs, insulating hooks, trolley wire hangers and stays and clamps.

Capt. C. F. Dunderdale, of the Rookery, has secured the contract for the electric light plant for the new building of "the Fair" for the Sperry Electric Company and the Standard Electric Company, of Chicago. The Sperry Company will furnish 450 arc lamps and the Standard Company 3,000 incandescent lamps. The apparatus of the Standard company is manufactured in the same building as the Sperry apparatus.

The Baltimore Electric Refining Company's new buildings at Baltimore, Md., will be made of iron designed and built by the Berlin Iron Bridge Co., of East Berlin, Conn. The rolling-mill will be 56 feet in width by 180 feet in length. The refinery building will be 130 feet in width by 80 feet long, and the boiler-house will be 49 by 50 feet. The buildings will be entirely of iron, no wood work being used about the construction in any way.

Geo. H. Thurston & Co., of Providence, R. I., have issued to the trade the following notice: "We desire to notify the trade and public that we have purchased the business of Mr. J. F. Hedge, Jr., electrical engineer, of this city, including all outstanding contracts, etc., payments on which should hereafter be made to us, and that we have also secured the services of Mr. Hedge, who will hereafter be found at our place of business, No. 59 South Main street."

The Sun Arc Lamp.—The Great Western Electric Supply Company, of 190 and 192 Fifth avenue, Chicago, has recently placed on the market a new arc lamp designed for either arc or incandescent circuits, which is known by the above title. It is manufactured exclusively by this company under patents lately granted. Although the lamp has been on the market but a short time, the company reports quite a number of sales and several duplicate orders from different companies.

Mr. Theodore Larbig, for the last 12 years with the insulated wire department of Holmes, Booth & Haydens, has severed his connection with that company, and will hereafter act as general agent for the United States for the Phillips Insulated Wire Company of Pawtucket, R. I., manufacturers of "K K" insulated iron and damp-proof office wire now used by many telegraph and telephone companies. Mr. Larbig will be located in New York, and is so well known to the trade that his success is already assured.

The Sunbeam Lamp.—Mr. J. H. Cooke, the general manager of the Sunbeam Lamp Company, Chicago, may certainly congratulate himself on the splendid showing the Sunbeam lamp has made during the first year of the company's life, and of the record showing that on the company's first anniversary more than 100,000 Sunbeam lamps were in daily use. It is also worthy of note that many of these lamps are in daily use in street-railway service, the filament being sufficiently strong to withstand the vibration caused by the jolting of the cars.

The Northwest Electric Engineering Company, of 170 Second street, Portland, Ore., has secured control of the firm of Shurtz, Tobin & Cannon. The Northwest Company has recently moved into its new store, and will now be in a better position to attend to its greatly increased trade. This company is the Northwestern agent for the following Eastern electrical companies: Eddy Electric Manufacturing Company, of Windsor, Conn.; the Partrick & Carter Company, of Philadelphia, Pa., and the Fort Wayne Electric Company, of Fort Wayne, Ind.

The Rochester (N. Y.) Machine Tool Works is installing many of its "Acme" automatic safety engines in isolated electric light plants throughout the country. Among recent installations are the following: Agustey's confectionery store, at Buffalo, N. Y., one three h. p. plant, being used to run 32 incandescent lamps, for heating the building and for operating the ice-cream freezers; Matthew Weiss, Pittsburgh, Pa., one four h. p. plant, operating a 20-light dynamo, at a cost of 10 cents per lamp per month, and also supplying power for the elevator. Many other "Acme" steam plants in Philadelphia, Omaha, etc., etc., have been installed.

The Thomson-Houston Electric Company, through its Chicago agency, has made the following isolated installations: Thos. Kane & Co., of 137 Wabash avenue, Chicago, one 50-light incandescent plant, to run in connection with a Regan vapor engine; Wm. Ruehl Brewing Company, of 224 West Twelfth street, Chicago, one 200-light incandescent plant; Hager & Johnasen Manufacturing Company, of Marquette, Mich., 250-light incandescent plant; Ranken & Fritsch Foundry and Machine Company, of St. Louis, Mo., one 18-light arc plant; and for Morrisson, Plummer & Co., of 200 Randolph street, Chicago, one 250-light incandescent plant.

The Pittsburgh Boiler Scale Resolvent Company, of the Eisner Building, Pittsburgh, Pa., manufactures a most efficient boiler scale preventive. Many methods for preventing boiler scale are in vogue, but the most successful way employed is the use of a heavy natural oil having a vaporizing point in excess of the boiler temperature, and deprived of its tar and wax, which, if left in, would unite with the sediment in the boiler and form a substance resembling putty, and which would settle on the sheets and be worse than any scale. The oil manufactured by this company so prepared is compounded with certain elements which aid greatly in dissolving scale. It is applied with a hand syringe to the inside of the boiler when it is empty and dry, and wherever it touches it forms a gloss on the iron to which no scale will attach itself. The surplus oil acts on the mineral sediment, and so long as a small quantity remains in the boiler the mineral will remain in solution until it can be washed or blown out.

The John Stephenson Company, car builders, of East Twenty-seventh street, New York city, has purchased the property known as the Birnie farm, between Larchmont and Mamaroneck, on the New Haven Railroad, and will erect extensive car works on it. The property comprises about 35 acres. It is the intention of the company to begin at once to prepare the ground for the erection of the buildings. The new works will probably be the largest and finest in the country. The business has increased so much lately that the present quarters in Twenty-seventh street, which occupy eleven city lots, have become far too limited, and a change was found necessary to enable the company to enlarge its facilities. Larger cars, especially larger electric and cable cars, are demanded, and in the new factory special arrangements will be made to build these cars. The company will retain its valuable property in Twenty-seventh street for the present. It expects to have the new factory in working order inside of two years.

The Eureka Tempered Copper Company, of North East, Pa., reports that its largely increasing business has necessitated additions to the capacity of its plant. The foundation for a new molding room, 50 × 140 feet, is now being laid. It is hoped that the increased facilities which this addition will afford may enable the company to meet the increasing demand for its tempered copper. Large orders are reported during the last 30 days from the Edison General Electric Light Company, of Schenectady, N. Y.; from the Wenstrom Consolidated Dynamo and Motor Company; the Electro-Dynamic Company; the Wightman Electric Manufacturing Company; the Thomson-Houston Electric Company; the Baxter Electric Motor Company; the Sperry Electric Mining and Machine Company; the C. & C. Electric Motor Company; the La Roche Electrical Works; the Shaw Electric Crane Company; the Thomson Electric Welding Company; the Colburn Electric Manufacturing Company; the Ford & Washburn Electric Company, together with a large number of orders for railroad car bearings.

The Electric Mutual Insurance Company.—A circular of information has been issued by this Boston company which gives some interesting facts regarding the first year's business. Its rate of premium on acceptable risks averages about one per cent. per annum, and dividends, by reason of its scientific and business-like methods, and which will be paid at the termination of each policy, are expected to materially reduce that rate. The company received its charter in May, 1890, and issued its first policy on the 15th of that month. The first 11½ months have yielded over $47,000 in premiums. Although the expenses incident to the first year have necessarily been large, the company has declared a 20 per cent. dividend payable on premiums expiring in May, 1891, and added an equal amount to reserve. The company insures all circuits outside the generating station, including lamps, converters, meters, motors, switches, inside wiring, etc.—the circuits completed—at about the same rate as the station, provided the insurance is made for the aggregate value of the property, exclusive of poles and wires. The principle upon which the Electric Mutual works is to have its risks brought up to its standard by removing any apparent unnecessary hazards, in order to reduce the chances of fire, and to have each risk supplied with adequate means for extinguishing fire, such as good, reliable hose, constantly attached to hydrants in convenient locations in both boiler and dynamo rooms, the hose to be supplied by city water (where there is such) and boiler pumps also, so that two sources of water supply will be available. The risk will then be entitled to a minimum rate according to its class.

Messrs. Lloyd & Paxton, Limited, of No. 2 Wall street, this city, are making a storage battery which possesses some distinctive features. The advantages claimed for it are, mechanical perfection, light weight, long life, and an ability to endure a high rate of discharge. The cell is made throughout by machinery and weighs about 25 per cent. less than the usual type of lead cell. A circular recently issued states that the firm is prepared to guarantee a rate of discharge 75 per cent. higher than that possible with any other battery now in commercial use. The weight of the standard street railway cell of this type complete is 35 pounds, and the ampère hours guaranteed for it 150. Ninety-six of these cells are employed for a 16-foot car. The normal rate of discharge is 50 ampères, and the normal rate of charge 40 ampères. It is said that a rate of discharge of 100 ampères can be maintained for half an hour with a drop in electromotive force to only 1.9 volts per cell. The capacity of the grid machine used in the manufacture of plates is 6,000 per day, or, with 21 plates per cell, 300 cells per day. The company claims that the high rate of discharge is obtained by an absolutely even distribution of metal throughout the grid, by a large number of perforations in the plate making a wide area of contact with the active material, and by using thin plates and more of them than has been customary. Thin plates are made possible by the character of the metal that is used and also by the process of manufacture. A prominent feature of the cell is the way in which the active material is held in the perforations of the plate. Besides the cells employed for railway work the company will manufacture a special type for service in electric light plants.

The Falls Rivet and Machine Company.—The manufacture of power transmission machinery is one of the many industries benefited by the wonderful growth in the application of electricity to lighting, railway and other commercial purposes and nowhere can this be observed more clearly than in the extensive works of the Falls Rivet and Machine Company at Cuyahoga Falls, O., where there is now in process of construction transmission machinery for the Louisville Electric Light Company, the Cincinnati Street Railway Company, the Louisiana Electric Light and Power Company of New Orleans, and for other well known electric plants. Among this machinery are friction clutch, pulleys and clutch cut-off couplings, 64 inches, 86 inches and 96 inches in diameter, with a transmitting capacity of 1,000 h. p., 1,200 h. p. and 1,600 h. p. respectively; steel shafting and hammered iron shafting 38 feet long turned to nine inches and larger in diameter; and self-oiling ring bearings 48 inches long arranged for the 13-inch shafting. The works are lighted throughout by electricity, this company being one of the first in the country to adopt the electric light. The plant consists of 50 Brush arc and 250 Jenney incandescent lamps. The engines employed are the Armington & Sims, the Buckeye and the Russell engines. The officers of the company are well known and honored in business circles, Mr. E. L. Babcock being the president; J. A. Long, vice-president; Samuel Higgs, treasurer, and Mr. H. J. Stambaugh, secretary, while Mr. E. D. Schmidt is superintendent of the shafting and pulley departments. An interesting feature in one of the departments is the manufacture of iron rivets, an industry established by Mr. Babcock's father in 1870.

Business Notice.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Company, of 105 South Warren street, Syracuse, N. Y.

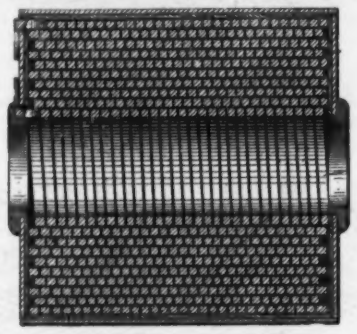
OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

U. S. PATENTS ISSUED MAY 12, 1891.

451,909. Brush-Holder; Harry H. Blades, of Detroit, Mich. Application filed Aug. 14, 1890. A brush-holder and its supporting shaft, a leaf-spring having both ends free and supported on said shaft independent of the holder, one free end of the spring adapted to bear on one side of the holder and the other free end on the other side.

451,921. Secondary Battery; Julius Emner, Jr., of Washington, D. C., Assignor by mesne assignments to Philip T. Dodge, trustee, of the same place. Application filed July 9, 1889. In a secondary battery, an element composed of aluminium provided with an active material.

451,922. Automatic Toll-Box; Isaiah H. Farnham, of Wellesley, Assignor to the New England Telephone and Telegraph Company, of Boston, Mass. Application filed Feb. 13, 1891. In an automatic toll box for telephone pay stations, the transmitter-battery, the direct circuit thereof, and the induction coil primary included therein, of a normally discontinuous shunt circuit, arranged round the said battery or primary helix, and a series of pairs of contacts or circuit-closers adapted, respectively, to close the said shunt-circuit and thereby to shunt the battery current



No. 452,003.—Electromagnet.

from the said primary helix, the several pairs of contacts being arranged in the path of a coin deposited in said box.

451,933. Coupling for Electric Wires; Andrew M. Hunt, of Newark, N. J. Application filed December 29, 1890. A coupling for electric wires, consisting of a metal sleeve having an internal diameter not less than the combined diameters of the wires to be joined and adapted by twisting to bind the enclosed wires together and conform to the external surfaces of the wires.

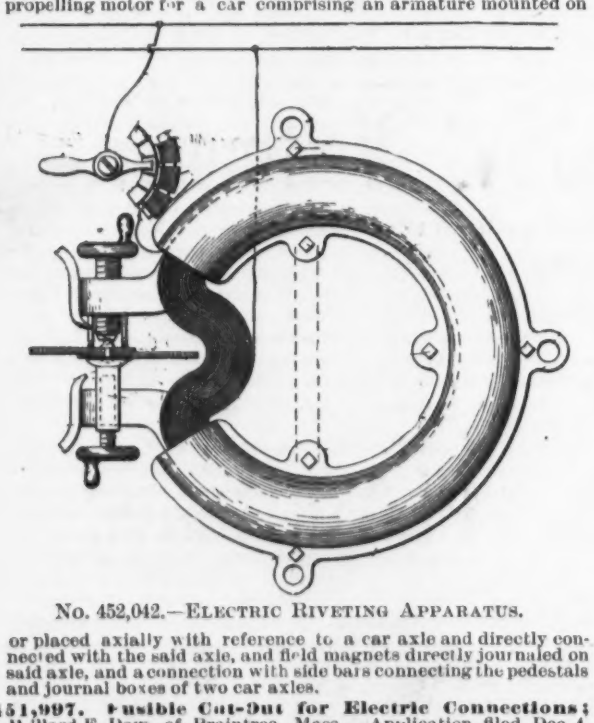
451,948. Galvanic Battery; Geo. C. McCullough, of Richmond, Ind., Assignor of one-half to Wm. P. Cook and Wm. A. Baumer, both of same place. Application filed Sept. 3, 1890. A galvanic battery cell provided with positive and negative elements and supplemental positive and negative elements, whereby one pair of elements may be used while the other pair is permitted to rest.

451,950. Electric Insulator; Samuel Oakman, of Melrose, Mass. Application filed Aug. 17, 1889. An insulator having a screw-threaded interior chamber and an exterior provided with a groove for receiving the wire, and a member forming an eye adapted to receive a line wire.

451,951 Printing-Telegraph; Edwin Pope, of Quebec, Canada. Application filed Feb. 18, 1888. In a printing-telegraph, a series of printing magnets arranged about a centre, a series of type-arms operated by the magnets, a series of detents, two arranged in the way of each type-arm, so as normally to prevent its operation, and a series of controlling magnets governing the position of the said detents, one of the said controlling magnets being in series with the said printing magnets, all in combination with relays adapted to respond to different conditions of a main line, and circuits and contacts controlled by the relays, whereby a succession of electrically different conditions on the main line will serve, when properly combined, to release one of the type-arms.

451,980. Electrically Propelled Car; Sidney H. Short, of Cleveland, Ohio, assignor to the Short Electric Railway Company, of same place. Application filed Nov. 6, 1890. An electric propelling motor for a car, comprising an armature mounted on and directly secured to a car-axle and non-rotative field-magnets mounted on springs independently of the said ar nature.

451,981. Mounting for Electric Car Motors; Sidney H. Short, of Cleveland, O., Assignor to the Short Electric Railway Company, of same place. Application filed Dec. 1, 1890. The propelling motor for a car comprising an armature mounted on



No. 452,042.—Electric Riveting Apparatus.

or placed axially with reference to a car axle and directly connected with the said axle, and field magnets directly journaled on said axle, and a connection with side bars connecting the pedestals and journal boxes of two car axles.

451,997. Fusible Cut-Out for Electric Connections; Willard E. Dow, of Braintree, Mass. Application filed Dec. 4, 1890. An electric cut-out, consisting of an insulating block and its annular insulating enlargement having radial slots, in combination with metallic plates on opposite sides of said block and enlargement and electric circuit and fusible cut-out wires held on said plates and the latter lying in said slots.

451,999. Electric Railway Signal; Willie Cowles Walter, of Richmond, Va.; Sophia Lee Walter, executrix of said Willie Cowles Walter, deceased. Application filed Nov. 13, 1889. In an electric railway signal, a line circuit, a switch-rail and a stationarily mounted coiled contact spring separate from and arranged in the path of said switch rail, parallel with the plane in which said rail moves to electrically engage said switch rail.

452,003. Electromagnet; Charles E. Lipe, of Syracuse, N. Y. Application filed Nov. 20, 1889. A practically solid coil of substantially rectangular naked wire having its individual convolutions and its layers of convolutions separated by layers of hard, insulating, fire-resisting material. (See illustration.)

452,005. Driving Mechanism for Electric-Motor Cars; Sidney H. Short, of Cleveland, O., Assignor to the Short Electric Railway Company, of same place. Application filed Nov. 1, 1890. An electric propelling motor, comprising a ring armature mounted axially upon a driving axle and directly secured thereto with non-rotative multipolar field magnets, the pole pieces of which are arranged to produce a field of force crossing the armature parallel to the plane thereof.

452,017. Electric Wire Suspender; Chas. A. Lieb, of New York. Application filed Nov. 8, 1890. A suspender for electric wires, comprising an insulating body part having at each end a hook-like device which are insulated from each other, and whereby it may be hung to another wire or support, and insulated means for attaching the trolley or other wire to it.

452,026. Electrical Signaling Device; Chas. J. Kintner, of New York, Assignor to the Electric Secret Service Company, of same place. Application filed July 15, 1890. A signaling instrument having one or more transmitting discs secured to a power-impelled shaft, and one or more circuit-making and breaking arms adapted to make and break circuit through said transmitting discs, in combination with a stop device carried by the shaft, and mechanical connections operatively connecting the circuit-breaking devices with the power-impelled shaft, whereby the signal is first automatically transmitted and the application of the power then checked.

452,035. Motor Car for Electric Railways; Sidney H. Short, of Cleveland, O., Assignor to the Short Electric Railway Company, of same place. Application filed Nov. 26, 1890. The combination, with a car and an electric propelling motor comprising a directly connected armature mounted on a driving axle and field magnets directly journaled on said axle, of a connection with another car axle, whereby said magnets are held from rotating.

452,036. Machinery for Propelling Electric Cars; Sidney H. Short, of Cleveland, O., Assignor to the Short Electric Railway Company, of same place. Application filed Dec. 9, 1890. In combination with a propelling motor having a support on a car axle by journal bearings and a truck frame, a motor holder, comprising a cross-bar having yielding connection with the motor frame in the middle and a yielding connection also with the truck frame at each end of said cross-bar.

452,041. Method of Braking Trains; Elias E. Ries, of Baltimore, Md., Assignor to Ries & Henderson, of same place. Application filed Oct. 4, 1888. The method of braking a traveling vehicle or train, which consists in retarding the rotation of the wheels by the application of mechanical friction and by increasing the frictional adhesion between the wheels and the rails by the passage of an electric current from one to the other.

452,042. Electric Riveting Apparatus; Elias E Ries, of Baltimore, Md., Assignor to Ries & Henderson, of same place. Application filed June 25, 1889. An electric riveting apparatus having a heading die of an anvil adjustable to and from the die, and an electric circuit including said die and anvil.

452,056. Apparatus for Heating by Electricity; Chas. Zipernowsky, of Buda-Pesth, Austria-Hungry. Application filed Sept. 16, 890. An apparatus for heating by electricity, comprising two conducting bodies so arranged relatively to each other that an imperfect contact of high resistance shall exist between them and said bodies included in the circuit of an electrical conductor. (See illustration.)

452,091. Process of Treating Conductors; James B. Williams, of Oakland, Cal. The process of treating an insulated electric conductor, consisting of a conductor surrounded by a dielectric with intermediate air spaces between them, which consists in first raising the said dielectric to a suitable temperature; second, passing warm dry air through the said air spaces and third, in maintaining the air under pressure in said intermediate air spaces.

452,099. Electric Railway; Mark M. Dewey, of Syracuse, N. Y., Assignor to the Dewey Corporation, of same place. Application filed Dec. 20, 1890. This invention consists in an electric railway having a portion thereof equipped with a conduction system and another portion equipped with an induction system.

452,151. Self-Controlled Motor-Switch; George Herbert Whittingham, of Baltimore, Md., Assignor to the Automatic Switch Company of same place. Application filed April 25, 1890. In a switch mechanism for electric motors, the combination of a single rigid pivoted hand-lever to which is connected one of the wires of an electric circuit and which is provided with two contacts, with a rheostat and a contact device, the rheostat connected to the armature of an electric motor and the contact device with the

No. 452,342.—Electric Cable.

field, the contacts of the hand-lever engaging the rheostat and contact device, and a holding device for said lever, consisting of a reciprocating slide mounted upon said lever and reciprocating across the pivot and to which is connected one extremity of a spring, the other end of which is fixed to any suitable point.

452,152. Thermal Cut-Off; George Herbert Whittingham, of Baltimore, Md. Application filed Oct. 18, 1890. In a thermal cut-off, the combination of a cup of refractory material, the edge of which is slotted, with a base of similar material having a socket circular in form and of the same diameter of the cup, into which the cup when inverted fits, and may revolve, section of fuse-ribbon inserted in the slot of the cup, the projecting ends thereof being bent over in contact with the exterior of the cup, and strips or brushes connected to the terminals of an electric circuit, which, when the cup is pressed between them, will make contact with the turned over ends of the fuse, and complete the circuit through said fuse, substantially as described.

452,160. Electric Railway; Francis O. Blackwell, of New York, Assignor to the Thomson-Houston Electric Company, of Connecticut. Application filed Nov. 23, 1888. In an electric-railway conduit, the combination, with an inclosed conductor, of a swinging support therefor.

452,165. Visual Indicator for Fire-Alarm and Other Purposes; Moses G. Crane and Fred W. Cole, of Newton, Mass. Application filed March 7, 1890. In an electric indicator, a series of parallel tapes, characters thereon, and let-offs for said tapes, combined with an electrio-magnet, its armature, an operating bar for the let-offs actuated longitudinally by the armature, and a stepped plate frictionally connected with a time-train and controlling the transverse vibrations of said operating bar.

452,166. Bell Striker; Moses G. Crane, of Newton, Mass. Application filed Nov. 17, 1890. In a bell striker, a bell hammer and two actuating pawls therefor, combined with locking mechanisms controlled by an electro-magnet for locking said bell hammer at the beginning of its advancing stroke.

452,173. Combined Coupling and Cut-Out; Joseph Devonport Finney Andrews, of Westminster, England. Application filed Oct. 27, 1890. The combination of a frame or casing, the terminals of the electrical conductors of the circuit, a block carrying a conductor for connecting the terminals, a spring for normally holding said block away from the terminals, a handle, a block moved by the handle toward and from the block which carries the conductor for uniting the terminals, and a spring interposed between the two blocks.

452,176. Electric Motor Car; John Christiansen, of Quincy, Mass. Application filed May 21, 1890. An electric motor car, having a motor connected with the car body, driving mechanism applied to each of the car axles and independent of the trucks or car body, and connected by an endless belt.

452,186. Trolley Stand; Robt. M. Jones, of Salt Lake City, Utah Ter. Application filed Dec. 29, 1890. A trolley stand, having a base-plate mounted elastically on the car body of an upright casing, mounted to turn thereon, and the trolley and its pole mounted elastically upon said rotary upright, whereby the trolley is permitted to adjust itself to the wires in both a vertical and lateral direction.

452,214. Electric Motor; Daniel J. Chisholm, of New York. Application filed Sept. 27, 1890. An electric motor, comprising a hollow frame having a series of radially extending arms or pole pieces arranged in pairs and carrying coils, an armature, consisting of a common shaft carrying independent pulleys to move between the pole pieces, said pulleys having coils held in sockets on their faces, and means for closing the circuit successively through the several series of armature and field-magnet coils.

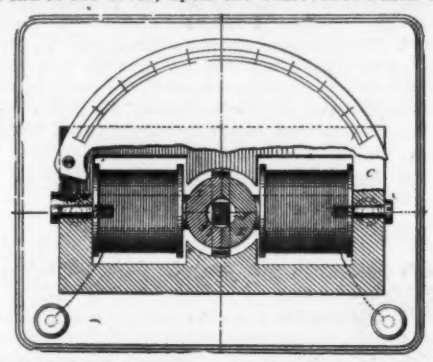
452,220. Surgical Electrode; Josephus H. Gunning, of New York. Application filed Nov. 20, 1890. A bipolar surgical electrode, having its two poles, which form component parts of the instrument itself, adjustable to vary their distance apart.

452,250. Electric Belt; Chas. D. Williams, of Silver Lake, Kan. Application filed Jan. 17, 1891. A cell for galvanic or electric belts made up of an outer casing of copper, the ends of which are bent to form eyes, a zinc element cruciform in cross-section maintained centrally within the casing by an interposed absorbent pad the zinc element being extended above the pad and copper element and perforated for engagement with the hooks of the conductors.

452,276. Electric Meter; Herbert W. Miller, of London, England. Application filed Nov. 21, 1890. An electric meter, having a counter or register, a single clock work, and a differential gear mechanism actuating the counter or register, of a coil arranged to receive the current to be measured or a portion thereof, and a rotating device connected with one gear of the differential gear mechanism, coacting with the coil to retard the differential gear mechanism, and thereby render the movement of the counter or register proportional to the strength of the current.

452,281. Railway Signaling Apparatus; James C. O'Neil, of Cleveland, O. Application filed June 30, 1890. The invention comprises two circuits, a circuit for the signal-controlling mechanism and a circuit for the signal. When the first circuit becomes operative, then the signal circuit is automatically made alive, and near the same time, or a little subsequent, the circuit for the signal-controlling mechanism is "cut out," leaving only the signal circuit inoperative.

452,288. Holder for Portable Electric Lamps; Wm. Wallace Savage, of Toronto, Canada, Assignor of one-half to Frederic Nichols, of same place. Application filed Feb. 20, 1891. The invention consists of a forked lever, pivoted on the base plate of the switch, and connected to a bell crank, the upper end of which is held for connection with the contact plate, which completes the circuit by the weight of the lamp held in the forked end of the lever, upon the removal of which lamp, how-



No. 452,326.—Electrical Measuring Instument.

ever, a spring arranged for the purpose forces the upper end of the bell crank into contact with the plate, which completes the circuit.

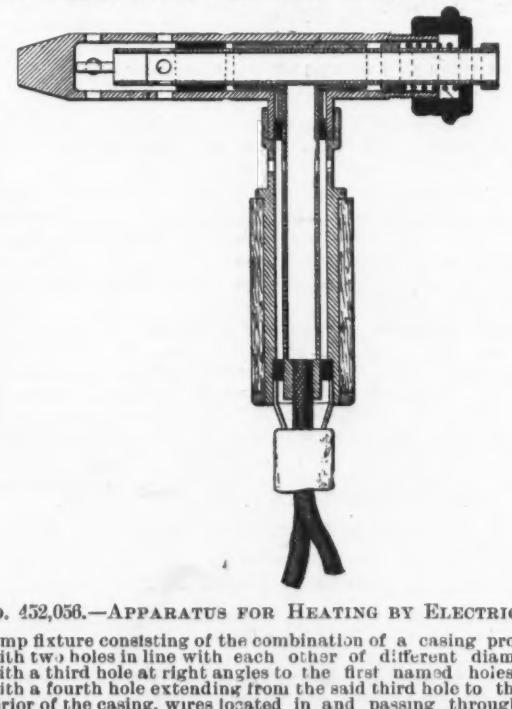
452,296. Electric Reciprocating Engine; Chas. J. Van Depoele, of Lynn, Mass. Application filed June 26, 1889. A system of distribution comprising three line or working conductors, a source of current of constant difference of potential in the circuit formed by two of said conductors, a source of pulsating currents of variable difference of potential, and means for directing alternately the pulsations of current therefrom through the circuits formed by the third conductor, and each of the other two.

452,299. Clock-Synchronizer; Arthur G. Wiseman, of Webster Groves, Mo. Application filed Dec. 17, 1890. In a clock-synchronizer a lever actuated by means of a magnet, said lever, when acted on by the magnet, having a compound movement, it being vibrated upon its fulcrum and at the same time tilted sidewise thereon.

452,303. Primary Battery; Walter Hanson, of London, England, Assignor of one-half to Frank Aldrich, of Washington, D. C. Application filed Feb. 4, 1891. A battery jar, a wooden frame fitted on the top thereof, positive and negative electrodes, two series of mercury cups, metal bars connecting the cups of each series, a copper connection between the positive electrode and one series of mercury cups, and a copper connection between the negative electrode and the other series of mercury cups.

452,305. Incandescent Electric Lamp; Wm. M. B. Keen and Wm. F. Haarmann, of New York, Assignors of one-fourth to Egbert Le Fevre, of same place, and said Haarmann, Assignor of all his remaining interest to said Keen. Application filed June 19, 1890. In an incandescent electric lamp, the combination of a tube located concentrically with and inside of a cylinder, the said tube and cylinder being provided with holes, a lever pivoted to said tube and passing through said holes and permanently in electric contact with one terminal of the filament of the lamp, and a spring pressing upon said lever in a direction parallel to the length of the lever, and located in said tube and forming one of the terminals of the lamp socket.

452,306. Incandescent Lamp-Socket; William M. B. Keen, of New York, Assignor of one-half to William Hidykiss, of same place. Application filed Sept. 15, 1890. An incandescent electric-



No. 452,056.—Apparatus for Heating by Electricity.

lamp fixture consisting of the combination of a casing provided with two holes in line with each other of different diameters, with a third hole at right angles to the first named holes, and with a fourth hole extending from the said third hole to the exterior of the casing, wires located in and passing through said smaller hole and terminating in said larger hole, which is for receiving the lamp whose terminals press against the terminals of said wires, a circuit closer for one of the wires located in said third hole, and consisting of a plug movable to and fro from the contact terminals of one of said wires and provided with a slot, a pin passing through said slot and fixed to said casing, the said plug being provided with a lateral notch, and a pivoted lever passing through said fourth hole and terminating in said notch.

452,326. Electrical Measuring-Instrument; Edward, Weston, of Newark, N. J. Application filed July 8, 1890. An electrical measuring instrument comprising a magnet having one pole concave, with its surface in proximity to the periphery of said annular pole, a rotary shaft or pivot extending through said annular pole, and a coil supported by said shaft and extending between said poles. (See illustration.)

452,340. Electric Cable; Wm. A. Conner, of Pittsburgh, Pa. Assignor to the Standard Underground Cable Company, of same place. Application filed July 21, 1890. An electric cable having its wires covered with saturated fibrous material so applied as to form an open mesh, thus providing air-spaces.

452,342. Electric Cable; William A. Conner, of Pittsburgh, Pa., Assignor to the Standard Underground Cable Company, of same place. Application filed July 24, 1890. An electric cable having a series of two or more wires covered with fibrous material, a wrapping of closely laid material inclosing the wires into a core, a coating of sealing material covering the wrapping, the sealing material impregnating and filling the interstices in the core at suitable intervals, and a lead sheath, tightly compressing the core at points where it is filled with sealing material. (See illustration.)